Freshwater aquaculture development in China

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215

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FAO Fisheries Technical Paper No. 215 FIR/T215(En)

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome 1983

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M-44

ISBN 92-5-101113-3

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PREPARATION OF THIS DOCUMENT

This document was prepared on the basis of the information collected in China during a study tour organized for the French-speaking African countries, by the Food and Agriculture Organization of the United Nations, with the financial assistance of the UN Development Programme.

The original document was published in French in 1981 under the title "Développement de l'Aquaculture Continentale en Chine".

Distribution:

FAO Fisheries Department
FAO Regional Fishery Officers
FAO Country Representatives
FAO Field/Aquaculture Projects
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For bibliographic purposes this document should be cited as follows:

FAO, Freshwater aquaculture development in
1983 China. Report of the FAO/UNDP study tour organized for French-speaking African countries. 22 April - 20 May 1980. FAO Fish.Tech.Pap., (215):125 p.

ABSTRACT

China's inland waters cover approximately 17 million hectares. For aquaculture purposes, they are subdivided into five regions and approximately 2.74 million hectares, mostly in southeast China, have been specially prepared. Almost 28 percent of this area is made up of fish ponds, the rest consist of lakes, reservoirs, rivers and channels. Freshwater fish production totalled 1 115 900 t in 1979. Fish culture accounted for 813 300 t, not counting almost 40 000 million fry. The 20 or so economically significant species are classified in three groups, the most popular of which comprises the four Chinese carps (grass, black, silver and bighead).

Fish culture has developed rapidly over the past 30 years, but especially since 1960, when use of controlled spawning of the Chinese carp became more widespread. The other reasons for this spectacular development are also given. Administrative organization at the central, regional and local levels, as well as the planning process are briefly described. The organization of the three institutes visited in Guangzhou, Shanghai and Wuhan, is described and their subjects of research given.

The different farming systems for producing fry and fingerlings, as well as fish for consumption are described next. The great majority of Chinese carp fry and fingerlings are produced in hatcheries, by means of controlled spawning in ponds or by artificial fertilization. The larvae are either sold or placed in a monospecies nursery pond where they reach 2-3 cm in less than a month. The fry may be transferred to a fingerling pond until they grow to between 12 and 30 cm. For this second stage, either single species or semi-intensive polyculture techniques may be used. It is usually carried out in a pond, but the use of floating cages and fish pens were also observed. Foodfish are produced in ponds using the semi-intensive farming system based on polyculture using organic manure and supplementary feeding. The principles used, the way they are applied and the results obtained are described in detail, while special sections on integrated development, tilapia farming and pond features are also included. The average annual yield in 1979 was 2 750 kg/ha. Harvest of up to 15 t/ha have however been obtained on a small scale.

Extensive fish culture in river and channel pens, in natural lakes and reservoirs is then dealt with on the basis of data collected locally. Average yields in 1978 were 308 135 and 90 kg/ha/year, respectively. In these environments too, fish culture in cages is developing rapidly and both extensive and intensive polyculture of Chinese carps is being practised.

Finally, the distribution and marketing of fry and fish for consumption, as well as two associated industries are briefly described. Conclusions as regards the organization of the study tour and the information it provided for French-speaking Africa and China, form the basis of a series of specific recommendations, geared to encourage future fish culture development in these two regions.

“给人一条鱼，　一餐就吃完。
教会人养鱼，　一生有鱼吃。”

"Give man a fish,
He will eat only once;
Teach him fish culture,
He will eat throughout his life".

ACKNOWLEDGEMENTS

The members of the study tour on Aquaculture Development, who visited China in April/May 1980, wish to express their sincere thanks to the Government of the People's Republic of China, the Food and Agriculture Organization of the United Nations and the United Nations Development Programme, who made this visit possible.

In China, the members had the opportunity of visiting different aquaculture ventures in the municipalities of Beijing and Shanghai, as well as in the provinces of Guangdong, Hubei, Jiangsu and Zhejiang. Everywhere and at all levels, they were welcomed with the same warm, cordial hospitality. They were impressed by the excellent organization of the tour, down to the smallest detail.

In particular, the members of the study tour wish to express their deepest gratitude to their many hosts at the National Bureau of Aquatic Products (NBAP) and the Regional Bureaux of Aquatic Products. Special thanks are extended to Mr Xio Fong, Deputy Director of NBAP; Mr Liu Lechuan, Director of the Department of Foreign Affairs of NBAP; Mr Li Renpei, Chief of the International Division FAD/NBAP, our most helpful cicerone and finally, to our tireless interpreters, Mrs Jia Yali and Mr Xi Jingming.

A.G. Coche
Team Leader FAO/HQ
Senior Officer (Aquaculture)
FAO/FIRI, Rome

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1. INTRODUCTION: THE STUDY TOUR AND THE PEOPLE'S REPUBLIC OF CHINA

1.1 Study Tour on Aquaculture Development in China

Since 1977, the Food and Agriculture Organization of the United Nations (FAO) and the Government of the People's Republic of China have been organizing annual study tours, for the purpose of training rural technicians from developing countries. Following the mission to China in 1976 by four FAO officers to study fishing and aquaculture in China's inland waters, it was recommended that FAO encourage "the use of Chinese expertise and experience ..." by means of "study tours for inland fishery administrators and planners, to provide them with new (or different) perspectives on their own problems" (Tapiador, *et al.*, 1977).

A first study tour on the development of aquaculture, for English-speaking African and Asian technicians was held in 1978 (ADCP, 1979). A second, on the same subject, was then organized for French-speaking African technicians. The tour left from Paris on 22 April and returned on 20 May 1980. The United Nations Development Programme (UNDP) provided financial assistance on the basis of regional project No. RAF/79/071. This report is based on the data collected during that tour.

Since aquaculture is one of the fields in which China has made considerable strides, interest was growing as to how it was organized and what technology was used, as well as to the possibilities of transferring them to other countries. The purpose of this study tour was therefore to give high-level African technicians the opportunity of observing the development of aquaculture in Chinese inland waters, the strategy practised, the methods used for drawing up policies and programmes, as well as the order of priorities accorded to them and their implementation. The members of the tour also had the opportunity of observing the principles on which development in these fields is based, how closely they are linked with agricultural expansion in general, and with integrated rural development in particular, as well as the organizational aspects of the overall development of production of aquatic products. They were also able to appreciate the facilities available to China for aquacultural research and training.

The group of 18 (Appendix 1; Figures 1 and 2)[1] arrived in Beijing on 23 April 1980 from Paris, led by the FAO/Africa Team Leader, Dr W.Q.-B. West, Regional Fisheries Officer for Africa. The FAO/HQ Team Leader joined the group the same day and took over leadership. Mr R. Li, Chief of the International Division of the Department of Foreign Affairs at the National Bureau of Aquatic Products and two interpreters took charge of the group on behalf of the Chinese Government. They were with the group during all their visits across the country.

When the tour was being prepared, FAO had indicated in advance the aquacultural activities which would be of particular interest to the group. Upon arrival of the group, the host government proposed a programme which included these suggestions and it was immediately accepted (Appendix 2). This programme enabled the group to visit several people's communes, production brigades and teams, as well as institutions which were distinguished in their respective fields. They clearly showed what could be achieved under conditions prevailing in China, but also allowed the group to assess whether it would be possible to transfer the Chinese experience to the participating African countries. The provinces of Guangdong, Hubei, Zhejiang and Jiangsu, as well as the Municipalities of Beijing and Shanghai (Figures 3 and 4) were visited.

---

[1] All photographs were taken by Dr A.G. Coche, Team Leader FAO/HQ, except for those attributed to Miss F. Botts, professional photographer, GII/FAO

Figure 1 The members of the study tour and their hosts at API, Shanghai

Figure 2 Visit by the study group to an ancient Buddhist temple, Guangdong

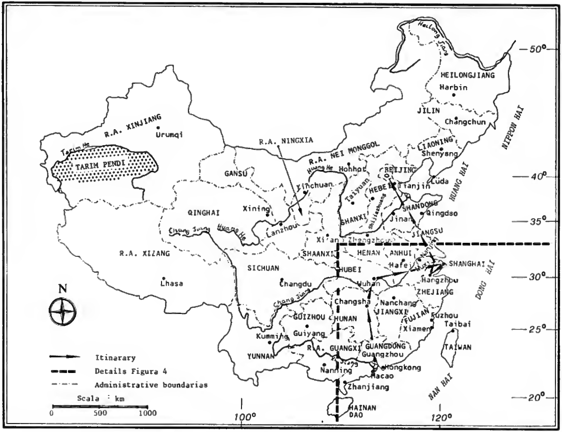

Figure 3 Genaral administrativa map of China and tha itinerary of the study tour

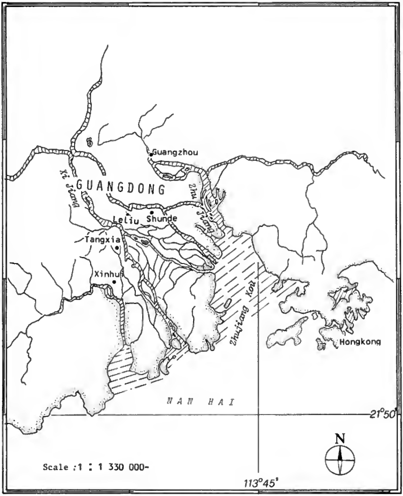

Figure 4a Location of the main installations visited in the Guangdong province

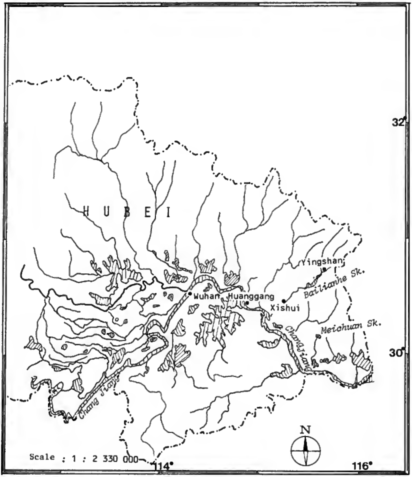

Figure 4b Location of main installations visited in the province of Hubei

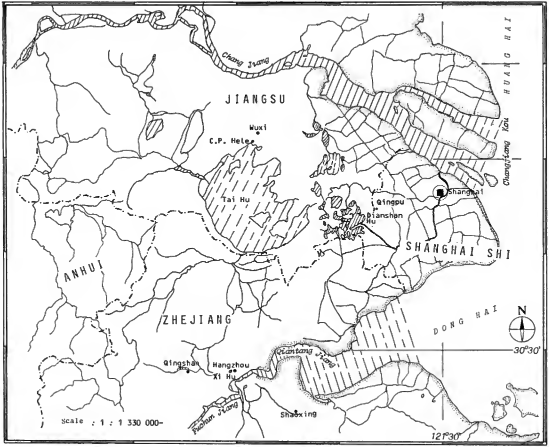

Figure 4c Location of the main installations visited in the Shanghai Shi and the provinces of Jiangsu and Zhejiang

The main aquacultural activities studied by the group were the following: state fish farms; fish farms run by people's communes, production brigades and teams, integrated production of fish, fish products and brood animals; extensive fish culture in lakes, reservoirs, channels and rivers; semi-intensive fish culture in ponds; intensive fish culture in concrete ponds; cage-farming; fish culture and hydrobiological research; large-scale egg, larvae and fry production; distribution and marketing of freshwater fish.

In most of the places visited, the technicians in charge, first gave a brief account of the conditions in which aquaculture had developed, the gradual increases in fish production and the means used to obtain them. This was followed by a guided tour of the installations and often included practical demonstrations (Figure 5). This gave rise to discussions, which continued later during question and answer sessions (Figures 6 and 10). This allowed the participants to obtain a lot of information, both in terms of quantity, as well as quality, on which this report is based.

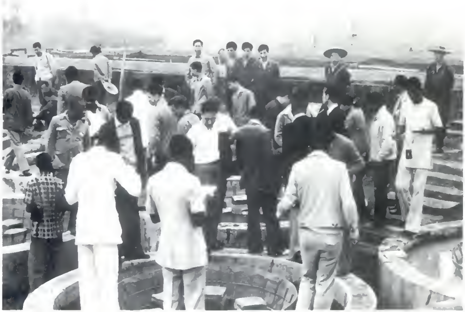

Figure 5 Visit to the fish culture installations of the Hengjiang fry centre, Xinhui district, Guangdong

Figure 6 Detailed briefing and general discussion with the technical officers of the People's Commune of Hele, Jiangsu

On several occasions, our hosts expressed interest in finding out about the fish culture techniques used in other countries. Two information sessions were held to provide this information. During these sessions, the technicians from the Institute of Aquatic Products of Shanghai and those from the Hele People's Commune (near Wuxi, Jiangsu) had the opportunity of listening to and taking part in discussions on papers presented by participants on subjects related to African fish culture. Slides were shown and commented upon by the FAO/HQ Team Leader. FAO technical papers on various aquacultural subjects were either distributed at the end of visits, or given to the National Bureau of Aquatic Products at Beijing. After the tour, further documentation was sent by FAO, Rome.

1.2 The People's Republic of China

The People's Republic of China, which is the third largest country in the world in terms of land area (approximately 9.6 million square kilometres) exhibits an extreme variety of topographical features and climatic zones. The northern and eastern edges of the western high plateaux of Xizang (Tibet) and Qinghai - located at an altitude of approximately 4 000 m - give way first of all to an intermediate zone of mountain chains and basins (1 000-2 000 m) and then to the eastern regions of hills and plains, usually sloping toward Dong Hai. Climate is as varied as relief. Temperatures and rainfall are determined by latitude (4°N-53°N), altitude and continentality (monsoon).

As a result, China is usually sub-divided into two distinct geographical regions (Figure 3). Western China (mainly Xizang, Qinghai, Xinjiang, Nei Monggol) is a vast region of very high plateaux - arctic climate due to altitude - and desert zones. Although there are many stretches of water in the Xinjiang, fish culture development is very recent and still relatively insignificant. Eastern China is itself sub-divided geographically into four main regions: (a) northeast, a vast undulating plain which in the west gives way to mountain chains; the climate is cold (average annual temperature -4°C to 10°C), winters are dry and summers warm; Heilongjiang, Jilin and Liaoning provinces; (b) north, plateau and loess plains: temperate continental climate (annual average exceeds 8°C), with hot summers; rainfall 250-750 mm/year; Beijing, Tianjin and the provinces of Hebei, Shandong, Henan, Shanxi, Shaanxi and Gansu; (c) centre, hills, mountains and valleys (Chang Jiang - tributaries and delta); sub-tropical climate, temperate to hot (monthly average temperature 6°-28°C), with a fairly long, cold, dry season; rainfall 700-2 500 mm/year; Shanghai and the provinces of Jiangsu, Zhejiang, Jiangxi, Anhui, Hubei, Hunan and Sichuan; (d) south, wide, coastal strip, hills and mountains, Xi Jiang and Zhu Jiang (delta) plains; hot, sub-tropical climate influenced by the monsoon (annual, average temperature 20°-22°C); rainfall, 1 000-2 500 mm/year; provinces of Fujian, Guangdong, Guizhou, Yunnan and the autonomous region of Guangxi.

From the administrative point of view, the People's Republic of China is sub-divided into 30 regions, which depend directly on the central government (Figure 3). These regions are divided into 22 provinces (sheng), 3 municipalities (shi) - Beijing, Tianjin and Shanghai - and 5 regions (zizhiqu) - Nei Monggol, Xinjiang, Xizang, Ninjxia and Guangxi. At the next administrative level are the 'districts' and 'cities'. In some cases, several districts are combined to form a 'prefecture'. The districts themselves are made up of several popular communes (Section 3.2).

The current population is almost 1 000 million, the great majority of whom live in eastern China. The main official language is based on the Beijing dialect, although many other dialects are spoken in different regions, such as the Guangzhou, Fujian and Shanghai dialects. As regards writing, the Chinese characters (simplified since 1949) are used, as well as the romanized version 'pinyin', which was made official on 1 January 1979. This report uses this transcription for the names of persons, places, rivers and lakes[1].

The total area of China is estimated at 960 million hectares. Forests occupy 12.7 percent of this area and lands permanently under cultivation, 10 percent, 45 percent of which are irrigated. The continental waters extend over 1.77 percent of the total area, as shown below.

The metric system of measurement is increasingly used, except for units of area which are still currently expressed in 'mu'. The data obtained by the group was converted to the metric system on the basis of the conversion factors given at the beginning of the report (page xiv).

2. FRAMEWORK FOR AQUACULTURE DEVELOPMENT IN CHINA

2.1 China's Aquatic Resources

Inland water surfaces in China cover approximately 17 million hectares, i.e., about 1.8 percent of the national territory (Zhu De-Shan, 1980). They are composed of different types of water surfaces, including rivers (approximately 50 percent), natural lakes (30 percent), reservoirs (11.5 percent) and ponds[2] (8.5 percent). It is currently estimated that 5 million hectares, i.e., 29.4 percent of these inland water surfaces could be suitable for aquaculture. To this must be added 10 million hectares of irrigated paddy fields, where aquaculture could also be envisaged (Anon., 1980).

There are four main drainage systems running from west to east toward the Dong Hai and Nippon Hai (Figure 3): the basins of the Xi Jiang, Chang Jiang, Huang He and Heilong Jiang[3]. Some of the features of these basins and rivers are given in Table 1. They are usually very wide and their flow is heavy and this often causes disastrous floods. Since

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1/ Reference: Anon., 1977 "Zhonghua renmin gongheguo feu sheng dituji (hanyu pinyinban)", Ditu chubanshe, Beijing. 169 p.(Atlas of the People's Republic of China by provinces - in pinyin)

2/ This includes any water surface of less than 1 000 mu (67 ha) in area, whether natural or man-made

3/ See Chinese-English glossary (page xiv) the Liberation in 1949, much construction development (dykes, dams, weirs) was done to regulate the flow and control the course of these large rivers (Tapiador, *et al.*, 1977). The result was a considerable increase in aquaculture potential, particularly in the valleys and plains of the middle and lower courses of the Xi, Chang and Huang rivers. In this regard, special mention must be made to the vast delta plains of these rivers. The aquatic fauna of these basins is very diversified. There are several hundreds of different fish species (Table 1), the majority of which belong to the cyprinid family (Anon., 1980).

The natural lakes of eastern China are found in the plain of the medium and lower reaches of the Chang Jiang (Figure 3), mainly in the provinces of Hubei, Anhui and Jiangsu (Section 9). In western China, there are many high altitude lakes in Xizang and Qinghai, which are fed by the surrounding mountain glaciers. In all, China has approximately 130 lakes which have a water area of 100 km² and which are found mainly in the Chang Jiang plain (Tapiador, *et al.*, 1977).

Many reservoirs have been built in China, most of them dating from after the Liberation. There are at present (*loc. cit.*) more than 280 whose capacity exceeds 100 million cubic metres, 1 800 medium capacity (10-100 million cubic metres) reservoirs and more than 10 000 of smaller capacity (0.1-10 million cubic metres). In all, they cover an area of 2 million hectares, 66 percent of which is used for extensive fish culture (Section 10).

From the point of view of production of aquatic products, China's resources in terms of inland water surfaces, are sub-divided into five Regions (Table 2). The two most important are:

- Region I, which includes the lower and middle courses of the Chang Jiang - especially the provinces of Hubei and Jiangsu, and
- Region II, which is centred in the lower courses of the Xi Jiang and Zhu Jiang and in particular in their vast delta in Guangdong province.

In the three other Regions, aquacultural production may be somewhat lower due to the presence of negative factors, such as a mountainous topography (Region III), colder waters (Region IV) or unfavourable socio-economic conditions (Region V). The most significant fish culture activities are therefore carried out in the south-eastern part of China, in the plains of the large rivers and in the coastal areas.

2.2 Use of Inland Water Surfaces for Fish Culture

At the end of 1979, 2.74 million hectares of inland water surfaces had been developed for fish production by a variety of farming systems (Zhu De-Shan, 1980). Almost 28 percent of these surfaces are made up of fish ponds, while the remainder consist of larger water surfaces (lakes, reservoirs, channels and rivers), where less intensive farming methods are applied (Table 3).

Pond farming is carried out by the people's communes, either as a main activity (fish culture communes) or as a secondary one (agricultural communes). While in the former, fish production is fully integrated with other types of production (usually pigs and vegetables), in the latter, it is carried out side by side with cereals, livestock and various other crops.

However, farming in lakes (natural or man-made), channels and rivers varies according to whether they are state-owned or belong to a people's commune, a production brigade or both.

2.3 Fish Production

Total output of freshwater fish for consumption reached 1 115 900 t in 1979. Fish culture accounted for 813 300 t (73 percent) and semi-intensive fish culture in ponds produced approximately 670 000 t (60 percent) (Zhu De-Shan, 1980).

Table 1

China's main drainage systems

Drainage system		Length of river (km)	Surface area[a] of basin (km²)	Annual flow ('000 million m³/year)	Average rainfall (mm/year)	No. of fish species[b]	Comments
River	English equiv.						
Xi Jiang	West River	2 129	437 230	356	1 480	260 (57.7%)	Large delta with the Zhu Jiang
Chang Jiang	Blue River (Yangtse)	5 800	1 808 500	1 020	1 050	300 (66%)	Delta: 80 000 km²
Huang He	Yellow River	5 464	745 100	48	415	140	
Heilong Jiang	Love River	4 354	-	-	-	90	2 965 km in China (border with USSR)

[a] From van der Leeden (1975) quoted by Tapiador, *et al.* (1977)
[b] Anon., 1980 (percentage of cyprinids in brackets)

Table 2

China's main aquacultural regions

Aquacultural region	Administrative region	Percentage water surface areas	Comments
I. Chang Jiang - lower/middle courses - delta: approximately 80 000 km²	Shanghai, Jiangsu, Hubei Zhejiang, Anhui, Jiangxi, Hunan	50	- Climate: subtropical, temperate; hot summers - Fry fisheries - Many lakes - Very high yields
II. Xi Jiang - lower course - delta with Zhu Jiang	Guangdong	17	- Climate: subtropical, hot - Fry fisheries - High yields
III. Huang He - lower course	Shandong, Henan, Hebei		- Climate: temperate, hot summer - Mountainous region - Main species: *C. carpio*
IV. Heilong Jiang - middle course	Heilongjiang		- Climate: cold - Main species: salmon and trout
V. Northwest	Xinkiang autonomous region		- Many large water surfaces; communications difficult; sparsely populated; fish culture development recent

Table 3

Freshwater areas developed for fish culture[a]

Category	Hectares	Percentage
Ponds	753 993	27.5
Lakes	1 254 040	45.9
Reservoirs	484 793	17.7
Rivers/canals	244 927	8.9
Total	2 737 753	100.0

[a] Situation end 1979 according to official statistics (Song, pers. comm., 1980)

The production trend for fish culture on the continent of China is given in Table 4. Over the last 30 years, food-fish production has quadrupled as a result of various measures taken, of which the main ones were:

(i) administrative organization;
(ii) distribution of resources;
(iii) the setting up of people's communes and the establishment of fishing communities;
(iv) the success of research on artificial spawning of Chinese carps in captivity (1958-61), and
(v) dissemination of methodologies developed at the fish stations.

Fish culture, which in 1950 was practised in the lower reaches of the Xi Jiang and Zhu Jiang (Guangdong province) and the Chang Jiang (Jiangsu and Zhejiang provinces) - where large numbers of wild fry could be caught each season - has since spread well beyond these geographical limits and has become largely independent of wild fry fisheries (Section 5). Although these fisheries still continue[1], their results no longer strongly influence fish culture development. Almost 40 000 million fry are now produced and distributed annually, over 95 percent of them in specialized fish culture stations (Anon., 1980).

2.4 Fish Species

The waters of the Chinese continent contain approximately 700 species of fish. In fish culture, however, only 20 or so species are economically important and three of these have only recently been imported. Among them, we must still consider three groups whose significance from the point of view of volume of production is declining (Table 5).

The four major species form the group of Chinese carps which are familiarly termed the 'family carps': the grass carp, the black carp, the silver carp and the bighead carp (Figure 7). The species of the second group are usually reared in mixed culture with the first, with the exception of the Japanese eel, which is produced according to intensive monoculture techniques. The species of the third group are produced only in certain areas and on a relatively small scale.

Although they are not 'carps' in the strict sense from a taxonomical point of view, the four 'family' carps and the mud carp all belong to the Cyprinidae. However, while the 'true' carp (*Cyprinus carpio*) is classified in the Cyprinid sub-family, the grass carp and black carp are Leuciscinae and the silver carp and bighead carps are Hypophthalmichthyinae[2].

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[1] The district of Xishui (Hubei province) produced almost 300 million fry in 1979, a third of which came from the Chang Jiang

[2] G.V. Nikol'skii's classification (1954), 1961

Table 4

Fish output in China 1950-79

Period	Freshwater food-fish (t fresh)	Reference
1950-60	300 000	Zhu De-Shan, 1980
1960-70	500 000	
1970	582 000	Zhu De-Shan, 1980 (Table 1)
1971	620 000	
1972	621 100	
1973	658 800	
1974	710 500	
1975	752 700	
1976	740 700	
1977	768 300	
1978	762 300	
1979	813 300	Song, pers. comm.

Table 5

Economically significant species in Chinese fish culture

Scientific name	French	English FAO[a]
A. Major species		
1. *Ctenopharyngodon idella*	Carpe herbivore	Grass carp
2. *Mylopharyngodon piceus*	Carpe noire	Black carp
3. *Hypophthalmichthys molitrix*	Carpe argentée	Silver carp
4. *Aristichthys nobilis*	Carpe marbrée	Bighead carp
B. Important species		
5. *Cirrhina molitorella*	Carpe de vase	Mud carp
6. *Cyprinus carpio*	Carpe commune	Common carp
7. *Carassius auratus*	Cyprin doré	Chinese gold fish (Crucian carp)
8. *Parabramis pekinensis*	Brème de l'Amour blanc	White Amur bream
9. *Megalobrama amblycephala*	Brème de Wuchang	Wuchang bream (Wuchang fish)
10. *Sarotherodon mossambicus*[b][d]	Tilapie du Mozambique	Mozambique tilapia
11. *Sarotherodon niloticus* [b][d]	Tilapie du Nil	Nile tilapia
12. *Anguilla japonica*	Anguille japonaise	Japanese eel (eel)
C. Less important species		
13. *Megalobrama terminalis*	Brème noire	Black bream
14. *Xenocypris argentea*	Sériole d'eau douce	Freshwater yellowtail
15. *Misgurnus anguillicaudatus*	Loche	Loach
16. *Plagiognathops microlepis*	Petites écailles	Small scale
17. *Salmo gairdneri*[d]	Truite arc-en-ciel	Rainbow trout
18. *Ophiocephalus argus*	Ophiocéphale	Snakehead
19. *Siniperca chuatsi*[c]	Poisson mandarin	Mandarin fish
20. *Siniperca scherzeri*[c]	Poisson mandarin tacheté	Spotted mandarin fish

[a] In brackets, English terminology used in China when it differs from that recommended by FAO

[b] Syn. *Tilapia mossambica* and *T. nilotica*

[c] De luxe predator species, little cultivated

[d] Exotic species

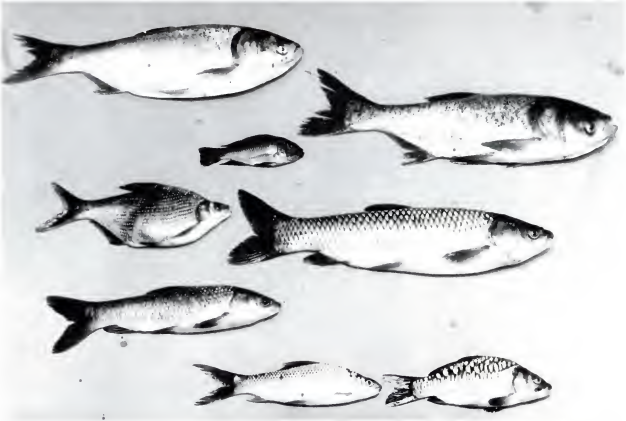

Figure 7 The main species cultivated in southern China: from top to bottom and from left to right, *H. molitrix* (silver carp), *S. mossambicus* (tilapia), *A. nobilis* (bighead carp), *M. amblycephala* (Wuchang bream), *C. idella* (grass carp), *M. piceus* (black carp), *C. molitorella* (mud carp) and *C. carpio* (common carp). Photo F. Botts.

From a thermal point of view, Chinese carps inhabit relatively warm waters. Their lowest thermal limit for growth is usually considered as 15°C, since their appetite declines rapidly in colder waters. They cease feeding under 8°-10°C (Anon., 1980). There are, nevertheless, some particular variations. The mud carp, for example, is a typically sub-tropical species, which is very vulnerable to cooling of its environment and it dies at 5.5°C. The bighead carp prefers warm waters (30°-31°C) and growth slows down considerably under 20°C. On the other hand, although silver and grass carps prefer warm waters, they continue to grow relatively well in cooler waters (15°-20°C).

Chinese carps - and the mud carp in particular - withstand a low dissolved oxygen content relatively well. This should nevertheless be preferably above 2 mg/litre. Below this level the fish lose their appetite and cease feeding when it falls below 1 mg/litre. Death ensues when the oxygen content is less than 0.2-0.5 mg/litre (Anon., 1980).

The natural diet of Chinese family carps and the mud carp is given in diagram form in Table 6. From the time they are 6.7 mm long (approximately 3 days old), the young fry feed actively on microzooplankton. The size of the planktonic organisms ingested increases gradually until the fry reach a total length of 14-16 mm. Their diet then begins to differ depending on the species and gradually evolves toward the preferred diet of each species. This becomes apparent in the silver and bighead carps from the length of 3 cm, while the three other species must reach 10-15 cm. From the fish culture point of view, these diets may be summarized as follows:

- plankton feeders: silver (phyto) and bighead (zoo-) carps
- macrophytic feeders: grass carp
- detritus feeders: mud carp
- mollusc feeders: black carp

Other species (Figure 7) are usually used in mixed culture with the major species (Section 6.1), e.g., Wuchang bream (macrophytic feeder), the common carp and the crucian carp (benthos feeders), as well as various ichthyophagous species (snakeheads and mandarin fish).

From a biological point of view, one of the other significant aspects of fish culture is the preference shown by different species for well-defined areas of the body of water in which they live. Choice of zone is made by Chinese carps mainly on the basis of diet (Table 7). This is why the plankton feeders prefer the upper layers of the pelagic zone, while the grass carp inhabits the coastal zone. Mud carps, black carps and common carps live in the deeper benthic zones.

2.5 Farming Systems and Yields

At present, different farming systems[1/] are used in fish culture on the continent of China and they may be classified as follows:

(a) semi-intensive fish culture in ponds: polyculture, organic fertilizers (integration), little supplementary feeding;
(b) extensive fish culture in natural lakes and reservoirs: polyculture starting from fry in stock; usually little use of fertilizer and little supplementary feeding;
(c) extensive fish culture in pens, rivers and channels: polyculture starting from fry in stock; usually little use of fertilizer and little supplementary feeding;
(d) extensive fish culture in cages: mono or polyculture in lakes, reservoirs, rivers or channels; little supplementary feeding, and
(e) intensive fish culture in pools: monoculture in warm water of eels for export.

Other farming systems are used, but these are in the experimental stages, i.e., intensive cage farming. Further details based on data obtained on the spot, are given in the following sections.

[1/] The different fish culture systems, based on the diet given to the fish, are defined as follows: extensive (natural feeding); semi-intensive (supplementary feeding) or intensive (artificial feeds)

Table 6

Natural diet of major Chinese carps

Approximate total length (mm)	Silver carp	Bighead carp	Grass carp	Mud carp	Black carp
7–11	copepod and rotifer nauplii				
11–19	micro-cladocera and rotifers especially cladocera			+ phytoplankton and organic detritus	copepods cladocera cladocera chironomids (benthos) detritus
19–30	cladocera copepods (rotifers) phytoplankton increases gradually	cladocera copepods rotifers phytoplankton zooplankton increases gradually	cladocera and copepods chironomids and benthic organisms + plant fragments	+ organic detritus phytoplankton	gradual increase of molluscs (gastropods)
30–100	PHYTOPLANKTON zooplankton	ZOOPLANKTON phytoplankton	gradual increase - soft aquatic plants - leaves + young shoots	gradual increase epiphytic algae	
100–150			- aquatic plants - soft land plants	epiphytic diatoms green filamental algae plant detritus (zooplankton)	BENTHIC MOLLUSCS
150			HIGHER PLANTS	EPIPHYTIC ALGAE ORGANIC DETRITUS	

Table 7

Environmental features of Chinese fish species

Species	Natural diet	Zone of water area
Silver carp	Mainly phytoplankton and zooplankton	Surface and mid-water in pelagic zone
Bighead carp	Mainly zooplankton and phytoplankton	
Grass carp	Higher plants	Mid-water and bottom in coastal zone
Wuchang bream	Higher plants	
Mud carp	Aufwuchs (diatons) and refuse	Deep benthic zone
Common carp	Benthos	
Crucian carp	Benthos	
Black carp	Benthic molluscs	
Snakehead	Fish and shrimp	Mid-water and bottom

At national level (Table 8), average yield from extensive systems varied in 1978 from 90 kg/ha/year to 307.5 kg/ha/year, while in 1979, using the semi-intensive system in ponds, the yield exceeded 2 750 kg/ha/year.

Table 8

Average annual yields obtained with fish culture in China in different aquatic environments

Aquatic environment	Farming system	Year	Average fish yield (kg/ha/year)	Reference Comments
Reservoir	(b)	1978	90	Zhu De-Shan, 1980
Lake	(b)	1978	135	Extensive polyculture of the four family carps, starting from fry in stock
Fish pen	(c)(d)	1978	308	
River	(c)	1979	135-645	See Section 8.1
Channel	(c)	1979	300-1 350	See Section 8.2
Cages	(d)	1979	2 500-3 600	See Section 11.1
Cages	(exp.)	1979	41 000-58 000	See Section 11.2
				People's Daily (Beijing) 22 January 1980
Ponds	(a)	1979	3 750	National target
	(a)	1979	2 750^{+}	Yield obtained

(a) Semi-intensive in ponds
(b) Extensive, in lakes and reservoirs
(c) Extensive, in pens
(d) Extensive, in cages
(exp.) experimental

At the local level, however, yields vary not only with the type of farming system used, but also with the duration of the period of growth, which is dictated mainly by the local climate and the influence this has on the temperature of the water (Table 9). In southern China, carps grow practically all year long, while in the Chang Jiang basin, the period of growth is restricted to 7 or 8 months in the year. It becomes shorter as we move toward the north, where it is 5.5 months.

Table 9

Variation in duration of the growing period
for family carps in China (Anon., 1980)

Climate	Hot sub-tropical		Temperate sub-tropical	Cold
Drainage system	Xi Jiang		Chang Jiang	Heilong Jiang
	Middle course	Lower course	Middle and lower courses	Middle course
Period of growth[a], months	12	11	7–8	5.5
Average temperature of water during this period (°C)	27.2	25	22–24	20.2

[a] Period during which the monthly average temperature of the water is at least 15°C

A third factor which affects yields is the relative intensity with which the system is applied. This is particularly valid for the semi-intensive system in ponds, where the rates of stocking, fertilizing and supplementary feeding can vary widely in time and space and result in proportionally different yields (Section 6.1.5).

A few data provided by the technicians of the Xishui district (Hubei), allow us to compare the annual profits which can be obtained with the three most widely used systems:

Farming system and product	Annual output		
	Retail price Y/ha	Selling price Y/ha	Profits Y/ha
(a) Irrigated paddy field: paddy	600	1 200	600
(b) Semi-intensive pond food-fish	120	2 250	2 130
(c) Cage, extensive, food-fish	60 000	90 000	30 000

Although we were not able to define 'retail price', it would appear from the opinions expressed by these technicians, that there is no doubt that fish culture can be considered one of the most profitable rural activities.

2.6 Main Factors Contributing to Fish Culture Development in China

Fish culture in fresh water has been a traditional activity in China for more than 3 000 years. The first known Chinese monography on the subject dates back to the Fifth Century B.C. (Table 10). Other later writings also describe extensive fish rearing in open waters.

Table 10

Summary of the historical development of fish culture
on the continent of China
(Adapted from Anon., 1980, page 3)

Period in history	Fish culture development
Chou Dynasty (1122 A.C.-249 A.C.)	In 473 B.C., publication of 'Treatise on Fish Culture', by the fish culturist Fanli in Wuxi (Jiangsu), on common carp rearing in ponds
Han Dynasty (206 A.C.-220 A.D.)	Writings bear witness to extensive culture of the common carp in open waters
Tang Dynasty (618-906)	The Emperor banned fishing, sales and consumption of the common carp; polycultural rearing of the four Chinese family carps
Song Dynasty (960-1276)	Catching wild fry in the Chang Jiang and Xi/Zhu Jiang is very popular; transport and sales of these fry are organized
Ming Dynasty (1368-1644)	There is a lot of information available on fish management practices and the semi-intensive farming system is well known: fry stocking density, polyculture, multigrade method, feeding, manure, disease control, pond construction
Ching Dynasty (1644-1911)	Detailed descriptions of production seasons for fry of different species, separation of the latter and methods of transport
People's Republic of China (October 1949-)	- 1958: first success with artificial spawning in ponds using silver and bighead carps - 1960+: rapid progress in artificial propagation of different species allows fish culture to cease dependence on wild fry

Until early in the Seventh Century A.D., i.e., for at least 1 200 years, the attention of the Chinese fish culturists was focused solely on the common carp (*C. carpio*). This fascination with this single species ended abruptly during the Tang Dynasty (618-906 A.D.), when fate willed that the name of the Emperor be similar to the common name (li) of this species. Fishing, sales and consumption of all common carps was banned. Fish culturists therefore turned to other species of local fish. Since there was an abundance of wild fry of the four family carps, and since they could be easily fished in the large rivers (Chang Jiang and Xi/Zhu Jiang) and then reared together in ponds, they quickly became popular. Monoculture of the common carp was thus definitively replaced by polyculture of family carps, which is practised today.

Techniques for catching wild fry, transporting them, sometimes long distances and selling them, thus became part of the fish culture tradition (Table 10). For nearly 1 300 years, fish culture activities remained centred in the valleys of the Chang Jiang and Xi/Zhu Jiang, close to the source of eggs and fry. It is only since 1960, when artificial spawning of family carps was developed and brought into widespread use, that this close dependence gradually ceased (Section 5).

It is only over the past 30 years that fish culture techniques have developed rapidly, to the point where China has become the world leader in fish production. Several of the main reasons for this 'leap forward' have already been mentioned (Section 2.3), but the following have to be added to the list:

(a) the close relationship between agriculture and fish culture, combined with the widespread development of controlled irrigation, which enables maximum use to be made of lands and water;
(b) the spread of electricity in the rural areas, combined with the relatively low cost of electrical energy thus provided to the people;
(c) decentralization of production scheme preparation to allow the people to participate and to encourage them to undertake responsibility;
(d) the establishment of close links between education, research and practical application, by combining theoretical knowledge and practical experience, and
(e) motivation of the masses by means of the widespread use of slogans and discussion campaigns designed to promote aquaculture development (Table 11).

Table 11

Examples of slogans used for promoting aquaculture

Slogan	Comment
"Take grain as the key link and ensure an all-round rapid development of agriculture, forestry and aquaculture/fisheries"	- integrated farming - maximum use of resources
"Four seasons all of them green"	- continuous use of the land for production
"One-four, two-eight" (Solecki, 1966)	(i) Four general principles: practise fish culture everywhere; provide the necessary labour; assist individual enterprises, and improve work efficiency (ii) Eight management principles: sufficient depth of water; no stagnant water; good spawning; encourage good species; provide sufficient food; modernize tooling; eliminate disease, and strengthen management
"Five fixes, one reward", quoted by the 'October' Production Brigade, district of Xishui, Hubei	Decide on the size of the ponds, the yield to be obtained from them, the outlay required, the tasks to be carried out and the bonus/fine. Reward the output which exceeds the set target
"Three in one"	Planning and development must be achieved by using together: (i) the young, the not-so-young, the aged (ii) researches, technicians and peasants
"Where there is water, there should be fish"	Utilization of all water resources
"Three things local"	Produce larvae and fry locally, stock them locally and catch them locally

In its present stage of development, however, fish culture has not yet made a sufficient contribution toward a complete solution to the problem of providing fish for the population of China and average annual *per caput* consumption is only 5 kg. There are several reasons for this: the rate of utilization of freshwater surfaces is too low (less than 60 percent), yields are usually not high enough, research facilities are inadequate and there is a regional imbalance in production. Moreover, recent efforts in industrializing the country is resulting in increased pollution of the waters. In most ponds, rates of stocking, fertilization and feeding are low because fish culture inputs required to intensify the cultural systems are lacking.

In an attempt to increase production of aquatic products, current efforts are being directed mainly to increasing utilization of existing water surfaces and establishing new ponds (priority being given to the immediate outskirts of urban centres), as well as intensifying cultural systems, applying more advanced technology and developing scientific research.

3. ADMINISTRATIVE ORGANIZATION OF AQUACULTURE

3.1 Central and Regional Administrations

At the national level, the central administration for aquaculture - and fisheries in general - has been under the control of the National Bureau of Aquatic Products (NBAP) of Beijing since 1978[1]. This Bureau, which is managed by a Vice-Minister, is directly answerable to the Council of State for fish-culture development policy, fish-culture research schemes (Section 4), as well as for technical aspects of fish-culture education and training in collaboration with the Minister of Education. Table 12 shows this organization schematically. The National Bureau of Aquatic Products, with a staff of around 400, is sub-divided into 10 Departments as follows: Marine Fisheries, Inland Water Fisheries, Science/Education, Planning/Finance, Investment Constructions, Material, Fishing Equipment, Purchasing/Marketing, Fisheries Administration and Foreign Affairs (Zu De-Shan, 1980). The Department of Inland Water Fisheries is concerned with the technical development of aquaculture in China.

On a regional scale, the Governments of the municipalities, provinces and autonomous regions (A.R.) have all set up an administration to deal with questions regarding fish culture (fisheries/aquaculture), with the exception of the A.R. of Xizan and Taiwan province. Where fish culture activities are carried out on a large scale (Table 13), these responsibilities are undertaken by a Bureau of Aquatic Products and where they are done on a small scale, they come under a Fisheries Division, incorporated into the Bureau of Agriculture and Fisheries, the Bureau of Water Conservation or the Marketing Bureau. Although they are affiliated to their respective governments, the Bureaux of Aquatic Products and these Fisheries Divisions depend directly, from a professional point of view, on the National Bureau of Aquatic Products.

3.2 Local Organization: State Farms and People's Communes

Fish culture is carried out mainly in State farms or in the people's communes.

As an example of the former, the study group visited the State farm of Baitan Hu, in the district of Huanggang (Hubei), which currently farms 400 ha of water (Baitan Hu - Section 9.3 - ponds). When it was set up in 1951, it was run by 10 persons and the average output was only 75 kg/ha. Twenty-two years later, in 1973, there were 91 employees (8 senior officers and 2 technicians) and the average output had increased tenfold. In 1979, the State farm produced 51 million fry of 3 cm in size, 1 million stocking fry and 300 t of food-fish. The present target for food-fish is 500 t. Income from fish culture constitutes 80 percent of total income - other income resulting from the sale of lotus seeds (20 ha under cultivation), rice (13.3 ha), fruits (140 000 trees), pigs and transport. Staff are paid salaries, unlike those of the people's communes and their income is not affected by the yields obtained at the State farms.

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[1] The National Bureau of Aquatic Products is today called the 'General Administration of Aquatic Products'

Table 12

Organization chart: aquaculture administration

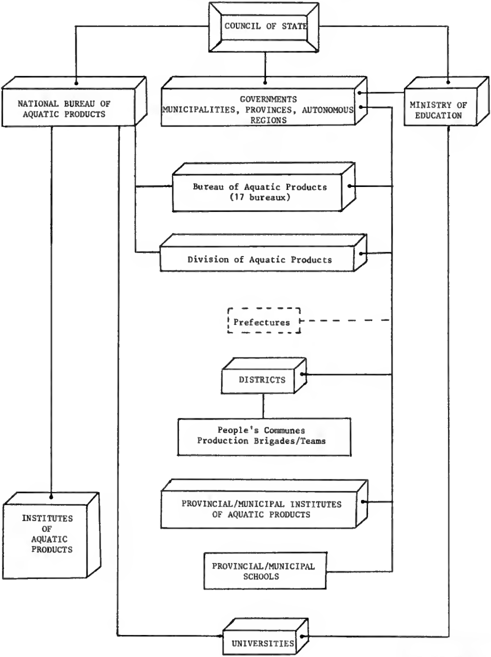

COUNCIL OF STATE
NATIONAL BUREAU OF AQUATIC PRODUCTS
GOVERNMENTS MUNICIPALITIES, PROVINCES, AUTONOMOUS REGIONS
MINISTRY OF EDUCATION
Bureau of Aquatic Products (17 bureaux)
Division of Aquatic Products
Prefectures
DISTRICTS
People's Communes Production Brigades/Teams
INSTITUTES OF AQUATIC PRODUCTS
PROVINCIAL/MUNICIPAL INSTITUTES OF AQUATIC PRODUCTS
PROVINCIAL/MUNICIPAL SCHOOLS
UNIVERSITIES

Table 13

Regional bureaux of aquatic products
(adapted from Zhu De-Shan, 1980)

(a) Municipal Bureaux of Aquatic Products (3):

Municipalities of Beijing, Tianjin and Shanghai

(b) Provincial Bureaux of Aquatic Products:

- (i) all maritime provinces and autonomous regions (8):
  Guangdong, Fujiang, Zhejiang, Jiangsu, Shandong, Hebei, Liaoning and the autonomous region of Guangxi
- (ii) some inland provinces and one inland autonomous region (6):
  provinces of Hubei, Jiangxi, Anhui, Quighai, Heilongjiang and the autonomous region of Xinjiang

The main role of the State farms seems to be to act as a back-up to fish culture development in the communes of the region, by carrying out applied research, by popularizing new techniques, training personnel and selling fry.

The organization of the Chinese people's communes has previously been described in detail (FAO, 1977). Their structure is a three-tiered one, with the family unit as the basic social component: the production teams are at the lowest level, the production brigades come next and then the people's commune itself. The latter, which is the basic unit of political power in the rural areas, administers all activities carried out on the commune's territory, including agriculture, industry, trade, education, social welfare and security. Members' incomes depend essentially on their individual efforts for the success of operations (points system) and on the profits obtained by the commune.

Fish culture in ponds is usually done by the production teams and brigades, while fish culture in lakes, reservoirs, channels and rivers is usually done by one or several communes combined.

The relative importance of aquacultural activities varies considerably from one commune to another. They may make only a small contribution to total earnings, or they may be a major source of income. The study group had the opportunity of visiting one of each of these types of communes. Their main features are given in Tables 14 and 15.

There are purchasing and marketing cooperatives at the communal level, which are in charge of distributing consumer goods and purchasing crops and fish which are not consumed locally (Section 13.2.2).

The people's communes plan their development to enable them to finance themselves as far as possible, in accordance with the well-established policy of self-reliance, which is the main guideline for rural development in China. Each commune must therefore not only produce enough food to meet its own needs, but in addition, must sell a fixed quantity to the State. This extra output is either distributed to other regions where it complements local products, or is stored for future needs.

Table 14

Main features of people's communes which are not specialized in aquaculture

People's commune	Shuangqiao PC Beijing	Hele PC Wuxi, Jiangsu
Total surface area	9 000 ha	3 600 ha
Population		
No. of persons	42 000	19 672
No. of families	9 000	6 607
Production brigades	13	6
Production teams	95	62
Integrated agricultural production	grain, pulses, fruits, dairy cattle, pigs, ducks, fish	mulberry trees, pulses, tea, fruits, silk-worms, dairy cattle, pigs, ducks, chicken, fish
Industrial production	insecticides, mechanics, bricks, wood-work, construction, etc.	35 different workshops
Annual average income *per caput*	Yuan 200	-
FISH CULTURE		
Production surface	80 ha	260 ha
Annual output	100 t food-fish	363 t over 74 ha
Farming system	semi-intensive polyculture	semi-intensive polyculture

Table 15

Main features of people's communes specialized in aquaculture

People's commune	Lelui PC Guangdong	'Liberation' PC district of Qingpu, Shanghai
Surface cultivated	4 950 ha	7 ha
Population		
No. of persons	91 000	
No. of families	17 000	
Production brigades	29	
Production teams	235	
Integrated, agricultural production	fish, sugarcane, mulberry trees, silk-worms, livestock (mainly pigs)	various
Industrial production	glass, paper, printing, plastics, alcohol, oil, tools, medicines, electronics, agricultural machinery, boats, insecticidas, limestone, bricks, etc.	factory for fish culture, machinery, aerators, granule-making machinery, mud pumps, transport crates, purifiers
Annual average income *per caput*	Yuan 260	Yuan 548
FISH CULTURE		
Production surface	2 400 ha/8 350 ponds	771 ha
Annual production	7 700 t food-fish 140 million fry	1 750 t food-fish 500 kg pearls
Percantage total income	30	-
Cultural system	semi-intensive polyculture	semi-intensive polyculture

The annual income of the salaried personnel of the State farms and the members of the people's communes varies. Whilst the former is fixed by the local Government, the latter not only depends on actual output, but also on output obtained over and above the fixed quotas (Section 3.3). Some annual income figures for 1979 (Yuan/person) were obtained by the study group as follows: Shuangqiao PC, Beijing - Y 200; Leliu PC, Guangdong - Y 260; 'Liberation' PC, district of Qingpu, Shanghai - Y 548; 'October' Production Brigade, district of Xishui, Hubei - Y 580. At the Baitan Hu State Farm in the district of Huanggang (Hubei), the average annual salary was Y 600. The senior officers' salaries reached Y 720. For the sake of comparison, it was pointed out that a market gardener working many hours overtime, could earn up to Y 900-1 000/year1/.

3.3 The Planning Process

Aquaculture development at all levels of production is an integral part of the Five-Year Development Plan and the Annual Development Plans. The planning process is relatively complicated and to a large extent, based on the two principles: "planning from the base up" and people's participation. Development objectives include quantities to be produced, minimum yields, taxes to be paid and purchases to be made to supplement local production. These targets are based on past performances and local development potential.

The central administration draws up a national development plan of production and distribution, on the basis of which it establishes objectives for each province (Table 16), municipality or autonomous region. These objectives are then discussed and reviewed in turn at each lower administrative level (e.g., province/district/commune). At commune level, the production brigades and teams are consulted. Many discussions are held, during which members' participation can be very important. At this level, and during revolutionary committee meetings, party members make sure that established political principles are respected. Production and purchasing targets are set in this way and a detailed plan is drawn up at the level of each commune. Gradually, through negotiation and successive adjustments, communal plans are upgraded to district level and these in turn to provincial level, before becoming national plans. Should there be serious disagreements on particular plans, they are sent back to their respective levels where new discussions are held in an attempt to reach an acceptable compromise.

These discussions, modifications and compromises always take into consideration the development guidelines set by the State, which always maintains effective control of production, through the use of input grants and marketing. Nevertheless, in spite of the State's significant role in the overall planning of production, the units of production draw up the details of the national plan and their approval of any modifications must be obtained.

4. AQUACULTURE RESEARCH AND EDUCATION

4.1 Aquaculture Research

Aquaculture research on the national scale is centralized in the National Bureau of Aquatic Products, which depends directly on the scientific research institutes of aquatic products (Table 12). The following six institutes (IAP) were operational in May 1980 (Figure 3):

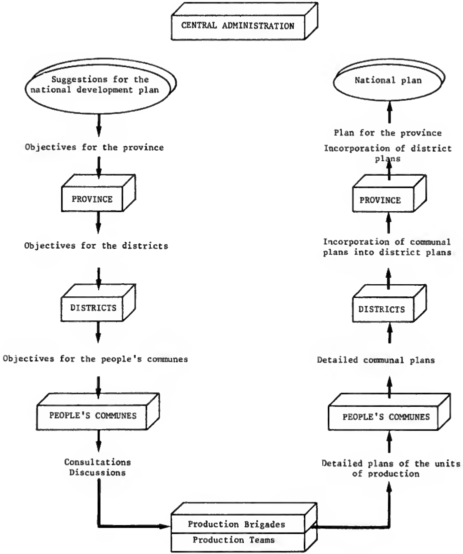
(a) concerned mainly with marine fisheries:

- IAP Huang Hai, in Qingdao (Shandong)
- IAP Dong Hai, in Shanghai
- IAP Nan Hai, in Guangzhou (Guangdong)

1/ The average annual income in the rural areas in 1978 was a little more than Y 70 per person (Beijing Review, 24 March 1980)

Table 16

Planning process in one province


CENTRAL ADMINISTRATION
Suggestions for the national development plan
Objectives for the province
PROVINCE
Objectives for the districts
DISTRICTS
Objectives for the people's communes
PEOPLE'S COMMUNES
Consultations
Discussions
Production Brigades
Production Teams
Detailed plans of the units of production
PEOPLE'S COMMUNES
Detailed communal plans
DISTRICTS
Incorporation of communal plans into district plans
PROVINCE
Incorporation of district plans
Plan for the province
National plan

(b) concerned mainly with inland water fisheries in China:

- IAP Heilong Jiang, in Harbin (Heilong Jiang)
- IAP Chang Jiang, in Shashi (Hubei)
- IAP Zhu Jiang, in Guangzhou (Guangdong)

A seventh centre, the Technological Research Institute was being set up in Shanghai.

In addition to these institutes, which are national in scope, there are many others, both provincial (e.g., the IAP of the Liaoning province in Lüda) and municipal (e.g., IAP Shanghai), which have considerable autonomy.

Aquaculture research is also carried out in State experimental farms, in the research institutes of the Chinese Academy of Sciences (Academia Sinica), in national or provincial universities and in colleges of agricultural fisheries, as well as at production level, in State farms and in some specialized brigades of the people's communes.

Aquaculture research is usually of the applied type, concerned with solving practical problems related to yields. This research policy is consistent with the philosophical slogan which encourages 'scientific research to serve production', by combining theory and practice, research and production, intellectual and manual efforts. The merits of academic research are not totally ignored, however, within the context of long-term development.

High priority was recently accorded to the institutes' scientific and technological efforts to help in the realization of an ambitious scheme of 'four modernizations'[1] by the year 2000. During visits to research centres, the study group was particularly impressed by the optimism and enthusiasm expressed by many of the staff at the sudden upsurge of official interest and support on the part of the central and regional authorities.

Visits were made to three scientific institutes in Guangzhou (IAP Zhu Jiang), Wuhan/Hubei (Hydrobiology Research Institute - Academia Sinica) and Shanghai (IAP Shanghai), where the programmes of activities were presented and discussed.

4.1.1 Zhu Jiang Institute of Aquatic Products

Until the end of 1978, this institute was part of the IAP Nan Hai. It has been independent since January 1979 and its programme of activities is geared to inland waters (Figure 8). Personnel numbers, 210 (58 technicians, 30 administrative, 122 workers). The well-known Professor Zhong Lui, 'father' of induced spawning in Chinese carps (1958) is Assistant Director of the institute. The IAP includes the institute itself (subsidized) and three fish production centres (self-financed). The study group was able to visit the institute and the main fish culture centres (20 ha), equipped with 70 ponds (i.e., 14 ha of water). Since it is located in a sub-tropical zone, the temperature of the water allows Chinese carps to be reared 11 months in the year. Average rainfall is 1 600 mm between April and September.

The institute has three major objectives: scientific research, production and training. For this reason, it is equipped with scientific sections, three production centres and one training centre.

At present there are five scientific sections, with research programmes focused on the following subjects:

---

[1] Modernization of agriculture, industry, national defense and science/technology

(i) Fish culture: induced spawning
(ii) Ichthyopathology: prevention and control of current diseases
(iii) China's fishery resources: inventory of the species in the Xi Jiang and Zhu Jiang basins in particular (260+ spp.); research into species of economic value; increase of their rate of spawning and production
(iv) Fish genetics: selection of inter- and intraspecific hybrids for improving fish yields
(v) Scientific information: training and extension

Two other scientific sections are being set up to deal with fish technology and the prevention of pollution, industrial pollution in particular.

The production centres practise an integrated farming system, producing fish, pigs, milk, rice, vegetables, fruits and green fodder. The system of fish culture used is semi-intensive, based on polyculture. Average output reaches 6-7.5 t/ha of food-fish.

In collaboration with the United Nations Development Programme (UNDP) and the Food and Agriculture Organization of the United Nations (FAO), the training centre has been holding courses for Asian countries since 1975. In April 1980, the seventh fish culture course (12 trainees from four countries) was being held. This will bring the total number of Asian technicians from 10 countries trained at this centre to 117. The training programme closely combines theory and practice, as a glance at the breakdown of the 374 h of the course will show: theory 32%, practical 20%, visits 24%, discussions 12%, examinations, revision 6% and other matters/free time 6%. The course, which was initially a six-month one, was gradually reduced to four months and then to three.

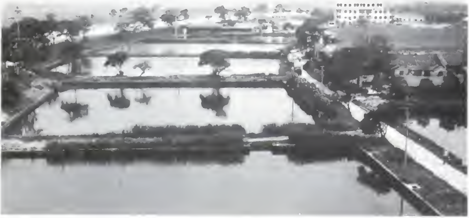


Figure 8 A section of the fish culture installations at the Zhu Jiang Institute of Aquatic Products, Guangzhou, Guangdong

4.1.2 Shanghai Institute of Aquatic Products

This municipal institute which was formerly part of IAP Dong Hai, has been independent since 1978. It employs 139 persons, including 49 researchers and technicians (Figure 1). It is sub-divided into a museum, three research laboratories and two supervisory offices (administration and research).

The museum, which was set up in 1958, has a collection of 1 500 specimens of the 2 500+ known fish species (800+ being freshwater species) in China.

The research laboratories and their programmes of activities are:

(i) Fishery resources: surveys on natural resources and environments; increasing these natural resources (introducing crabs, mullets, carp fry); cage rearing in lakes; regulating fishing; improving species reared in fresh water (selection, hybridization); controlling the introduction of exotic species
(ii) Aquaculture technology in ponds: increasing yield (to 15-22.5 t/ha); artificial feeding (trend toward more complete feeds, especially for black carps, so as to save the molluscs for human consumption); improving the quality of the fish; diseases of pearl-producing mussels
(iii) Industrial fish culture: development of urban industrial fish culture (either open, intensive systems or systems using partial or complete re-cycling); monitoring of environmental factors so as to reduce rearing time (e.g., in heated waters of a hydro-electric plant)

4.1.3 The Hydrobiology Research Institute of the Academia Sinica

This leading scientific institute, which was set up in Shanghai in 1950 and transferred to Wuhan (Hubei) in 1954, currently employs 250 research workers/technicians and 150 administrative officers and fish culture workers (Figures 9 and 10). In addition to a 6.67-ha fish farm, the institute includes the following six research laboratories:

(i) Ichthyology: a museum containing approximately 100 000 samples, which include 95 percent of the 800+ freshwater fish species found in China and 150 standard specimens
(ii) Genetics: induced spawning and physiology; hybridization
(iii) The aquatic environment: increasing fish production in lakes and reservoirs; monitoring ichthyophagic fish in reservoirs
(iv) Algology: taxonomy, ecology, physiology and genetics of freshwater algae; culture of cyanophyceae in paddy fields as a source of nitrogen
(v) Biology of aquatic pollution: pollution (especially industrial pollution), ecology and toxicology
(vi) Ichthyopathology: surveys/research on pathological parasites; study of viruses, research centred on cultured fry and disease prevention; use of local plants

4.2 Aquaculture Education and Training

Following the recent decision by the Central Government of China to 'modernize in four fields' before the end of the century, the need to have an adequate number of high-level scientific research workers and technologists and qualified technicians is acknowledged at all administrative levels. Scientific and technical training of this type of staff is considered essential.

The study group did not have an opportunity of visiting the universities of aquatic products, which are under the technical control of the National Bureau of Aquatic Products (Table 12) and are located in Shanghai, Zhanjiang (Guangdong) and Xiamen (Fujian). Studies there last four years and the student can choose from three sections (fish culture, fisheries and processing of aquatic products). Two other sections are now being experimented (boat building and electronics).

Other universities, which are not specialized in aquatic products, have an aquaculture section, e.g., the agricultural and marine universities.

Many technical schools at secondary level also offer specialized training in fisheries and aquaculture.

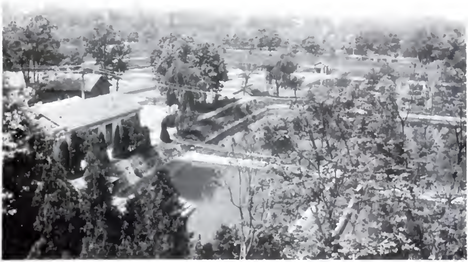


Figure 9 A section of the fish culture installations at the Hydrobiology Research Institute in Wuhan, Hubei

Figure 10 Briefing by and general discussion with Professor Yan Dashu, Assistant Director of the Hydrobiology Research Institute, Wuhan, Hubei

5. CHINESE CARP FRY PRODUCTION

Up until the early sixties, traditional Chinese fish culture depended totally on larvae and wild fry fished in the rivers. Not only did the numbers and species harvested vary from season to season, but the retail price for fry was relatively high. In addition, large-scale river management schemes (hydro-electric dams, flow control, irrigation) carried out after the Liberation quickly resulted in a serious reduction in the number of juveniles in rivers. The need to begin controlled spawning of reared fish became increasingly urgent and research on the subject was intensified. The first experiments conducted in 1956 on the use of pituitary hormones to control pond spawning of the silver and bighead carps were unsuccessful. Two years later, however, Professor Zhong Lin (Guangzhou, Guangdong) succeeded for the first time in obtaining the artificial spawning of these two species, hatching of 10 million eggs and producing 500 000 fry. This method was initially based on artificial fertilization of ovules obtained from mature females. It was improved in 1964 by the success of induced spawning followed by natural fertilization in fry ponds and this is the most widespread method used.

This new technology, which was quickly adapted for the induced spawning of all Chinese carps and for large-scale hatchery production of their fry, was then actively disseminated in the provinces. It was popularized even at fish farm level and soon became an integral part of the fish culture system.

Over 40 000 million fry are produced annually today, more than 95 percent of these in hatcheries (Anon., 1980). This has allowed fish culture to develop without being dependent upon the capture of larvae and wild fry. In some regions, however (e.g., middle and lower Chang Jiang and the western arm of the lower Xi Jiang), use is still made of this source of fry for stocking as a supplement to hatchery production. In 1979, in the district of Xishui (Hubei), for example, close to 100 million wild fry fished in the Chang Jiang were stocked in ponds, while 200 million fry were produced in hatcheries.

The study group had the opportunity of visiting several hatcheries and fry-rearing centres (Table 17), where the data given below were obtained.

Diagramatically, we can sub-divide the production cycle of stocking fry into three successive stages: production of larvae, production of small fry of 2-3 cm in length (nursery fry) and the production of fry of between 12 cm and 20 cm in length, for stocking (fingerling). Depending on the importance of fry as a source of income (Table 17), fry ponds usually cover 10-25 percent of the total area used for fish culture, although in some cases this percentage can reach 55 percent. The Hele people's commune (Jiangsu) was however advised to use 30 percent of their total area for fry production on a priority basis (with food-fish production taking second place), and 70 percent for the latter (with fry production taking second place), so as to utilize the water surfaces in the best possible way. When fingerlings are reared in ponds, this utilizes up to 90 percent of the fry and fingerling rearing area (Table 17). However, when fry alone are reared, up to 74 percent of the total area is used for the purpose. Fingerling rearing may be done in floating cages (Section 5.4) and in fish pens (Section 5.5).

5.1 Production of Chinese Carp Larvae[1]

The first stage in the production cycle of stocking fry consists of:

(i) stocking and preparation of the brood fish
(ii) spawning of the brood fish
(iii) incubation and hatching of the eggs

5.1.1 Rearing brood fish

Chinese carp brood fish are either reared in ponds or caught in lakes, reservoirs or rivers.

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[1] Subject treated in detail by Pagán-Font and Zinet (1980)

Table 17

Features of the fry and fingerling-rearing centres visited

Province		Guangdong		Hubei	
Fry-rearing centre[a]		1	2	3	4
Staff			81	27	
Area (A), ha		10	22.5	23.33	1.6
- Incubation	% A	-	0.05	-	-
- Nursery ponds	% A	9.1	74.0	-	8.1
- Fingerling ponds	% A	90.1	-	-	91.9
- Fingerling ponds A	% A	9	-	-	-
- Fingerling ponds B	% A	27	-	-	-
- Fingerling ponds C	% A	54	-	-	-
- Brood fish	% A	-	19.6	-	-
- Spawners	% A	-	0.1	-	-
Area, % A of total		23.1	100		13.6
Number of ponds (fry rearing)		45	80+	38	
Production (P), fry/year		140 million	394 million	51 million	
- 8 day-old larvae			360 million	-	
- Fry (3 cm)			34 million	50 million	
- Fingerling (15-20 cm)			-	1 million	
- Silver carp	% P	2.9	14	important	
- Grass carp	% P	12.9	18	fairly important	
- Bighead carp	% P	5.7	7	important	
- Mud carp	% P	71.4	61	-	
- Miscellaneous	% P	7.1	-	fairly important	
Cost of fry stocking, Y/10 000				500-600	

a/
1. Leliu People's Commune, Production Brigade
2. Xinhui district, Hengjiang fry-rearing centre
3. Baitanhu State Farm, district of Huanggang
4. 'October' Production Brigade, district of Xishui

At the Hengjiang fry-rearing centre (district of Xinhui, Guangdong), which is one of 17 hatcheries in the district, the 17 brood fish ponds cover a water surface of 4.40 ha, i.e., 19.6 percent of the total water surface of the centre. Their average surface area is 2 600 m², and they usually vary between 1.5 m and 2 m in depth, except in the case of mud carps, which require warmer water (depth 2-3 m and protection against cold winds). Sexes are mixed (F/M ration = 1:1 or 2:3) and each brood fish is used 2-3 times per year for 6-7 years.

Each pond is stocked with a majority of one type of carp and two or three other species. In 1 ha there may be a main stock of 150-225 grass carps (i.e., 1 000-1 250 kg) or 100-150 silver carps (750-1 000 kg), or 75-100 bighead carps (750-1 000 kg), with two or three different species bringing the total to 1 500-2 250 kg.

The stocking rate for the mud carp is high and can reach 2 250-3 000 specimens/ha, i.e., 2 250-3 000 kg/ha.

When the temperature of the water exceeds 15°C, artificial feeding is considered very important. It consists of rice bran and maize chips (daily ration 1-2 percent of the ichthyomass), as well as fodder (grass carps). Regular organic fertilizing keeps the pond adequately supplied with plankton.

It is also important to maintain a good circulation of water in the pond, to renew the latter frequently and to make sure that the quality and level is adequate.

5.1.2 Selection and preparation of brood fish

For spawning purposes, brood fish are not only chosen for their individual state of health and maturity, but also in accordance with the more general criteria given below:

Carp	Minimum age of females[a/]	Individual weight
Bighead	4 years	7-12 kg
Grass	5 years	8-12 kg
Silver	3 years	3-6 kg
Black	-	more than 10 kg
Mud	3 years	0.8-1.4 kg

a/ Age of males: generally a year younger than the females

Spawning time for Chinese carps depends mainly on the temperature of the water: optimum 25°C, minimum 20°C, maximum 31°C. At the Hengjiang fry-rearing centre (Guangdong), the spawning season extends on average from the end of March to the end of September and reaches its maximum yearly intensity in April and May.

Preparation for spawning of selected brood fish consists of:

(i) conditioning them to future manipulation, by successively catching them and setting them free, and
(ii) injecting a dose of hormone to stimulate final maturing.

The most currently used agents are fish gonadotrophin (extracted from the pituitary gland of the common carp, silver carp or bighead carp), human chorionic gonadotropin (HCG) and synthetic LH-RV analogous hormones. Pituitary collection from fish weighing more than 0.6 kg is done in the centres where food-fish are bought and sold (price: Y 0.05/pituitary in the district of Xinhui, Guangdong). They are treated and then preserved either in alcohol or dry, until they are used. The pituitary extract is prepared by grinding the gland in a normal saline solution (7.8 gm NaCl/litre). A brood fish usually requires 5-10 ml of solution, depending on its live weight (Figure 12). A few examples of different types of injections were cited; the dosages are given per kilogram of female brood fish:

(i) grass, silver, bighead carps: 4 mg of dehydrated common carp pituitary (HDCC);
(ii) bighead and silver carps: 1 100 international units HCG;
(iii) mud carps: 3.5 mg HDCC, and
(iv) grass carps: 0.01 mg LRH-A

At the Hengjiang fry-rearing centre (Guangdong), preparation of mud carp brood fish was demonstrated. After the brood fish had been chosen (maturity, health, sex ratio 1:1), a first injection is given to the females and the brood fish are stored in a net in a transit pond. Eight hours later, a second injection is given to the females and the first to the males. The brood fish prepared in this way are then placed in the spawning pond (Figure 13).

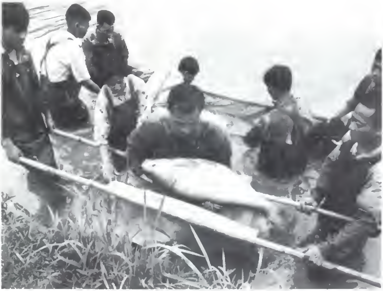

Figure 11 A silver carp brood fish is selected from the storage pond and placed in a canvas bag in which it will be transferred to the spawning pond (Photo F. Botts)

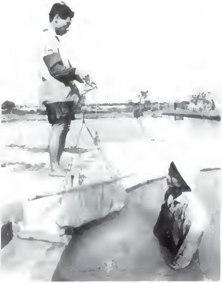

Figure 12 The brood fish is weighed to determine the dose of hormone necessary for it to reach final maturity (Photo F. Botts)

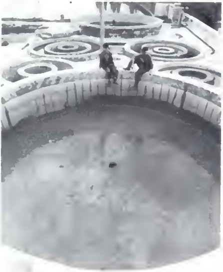

Figure 13 Spawning pond and round incubation ponds (background), comprising an automatic transfer system for eggs. API, Zhu Jiang, Guangzhou, Guangdong (Photo F. Botts)

5.1.3 Spawning of the brood fish

Until 1963, fertilized eggs were produced only by means of artificial fertilization of ova extracted manually by stripping the females (Figures 14 and 15). This method is still used, e.g., at the hatchery of Baitan Hu State Farm. Since 1964, however, natural fertilization in spawning ponds is preferred (Figure 13).

This method was demonstrated at the Hengjiang fry-rearing centre (Guangdong) with the mud carp. The spawning pond was an oval-shaped cement pond which contained 69 m³ of water and 230 brood fish of both sexes. Approximately 6 h after the second injection, the femalea spawn (preferably at dawn) and the ova are fertilized aimultaneously by the malea present. Approximately 30 min after egg-laying, the eggs (pelagic) were collected in a fine-meshed dragnet (Figure 16), while the brood fish were removed and transferred to their stocking pond. The quantity of swollen eggs collected amounted to 32.9-litre buckets, i.e., 288 litres of eggs. For the mud carp, the number of swollen eggs per litre is on average 63 000. More than 18 million eggs were therefore collected.

In other hatcheries, transfer of fertilized eggs can be carried out automatically from the spawning pond to the incubation pond by means of a system of valves and pipes, either before or after swelling (Figure 13).

Chinese carps show a relatively high rate of fertility (Table 18). The average ia approximately 50 000 ovules/kg of female, except for the mud carp (100 000/kg) and the black carp (25 000-30 000/kg). Fertilization rate is generally in the region of 80 percent.

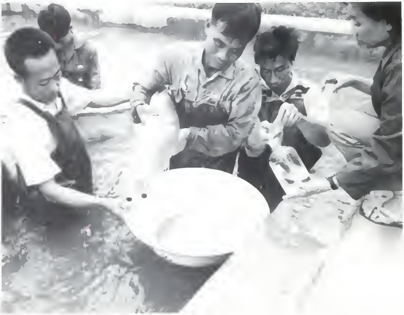

Figure 14 Stripping a mature female in order to carry out artificial fertilization (Photo F. Botts)

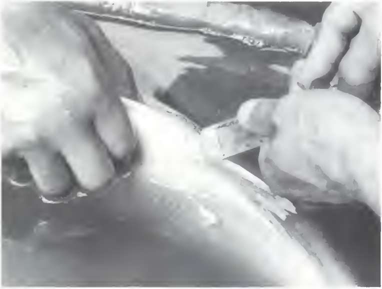

Figure 15 Milt is taken from the male with a syringe and is then used for artificial fertilization of female ova (Photo F. Botts)

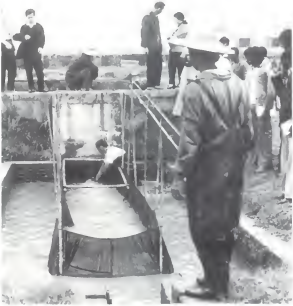

Figure 16 Collecting eggs after spawning and fertilization in the spawning pond. Hengjiang fry-rearing centre, Guangdong

Table 18

Potential and actual fertility of Chinese carps
(Adapted from Anon., 1980, page 22)

Species	Ovocytea average No./kg	Gonadosomatic ratio[a] (%)	Ovules obtained with artificial propagation		Size of eggs before swelling	
			Average No./kg	Maximum No./kg	No./g	No./ml
Grass carp	120 000	17.1	47 700	103 000	700–750	650–700
Bighead carp	124 000	17.8	58 800	77 600	650–700	600–650
Silver carp	141 000	20.1	51 800	75 400	700–750	650–700
Mud carp	240 000	16.0	100 000+		1 500	
Black carp	65 000	10.8	25 000–30 000			

[a] GSP = (weight of ovaries x 100): body weight

5.1.4 Incubation and hatching of fertilized eggs

Incubation of the eggs takes place either in round cement ponds (Figures 13, 17 and 21), or in jars (Figures 18 and 19), provided with a flow of water which allows them to remain in suspension. The period of incubation varies depending mainly on the temperature of the water. A relatively high temperature speeds up the development of the embryo. The silver carp would require 61 h incubation at 18°C, 35 h at 22°C and 18 h at 28°C. The temperature of the water must be relatively stable and between 18°C and 31°C. Optimum temperature for Chinese carps in general is between 22°C and 28°C.

At Hengjiang (Figure 17), the study group was able to observe egg incubation in a round pond (diameter 2.90 m; depth of water 0.8 m; volume 4.6 m^3), in which there was a flow of 3 rpm. This type of incubator, which is built of bricks, stone and cement, allows 700 000–800 000 eggs/m^3 to develop. The average hatching rate is 80 percent.

At the Baitan Hu State Farm hatchery on the other hand, incubation may also be carried out in clay jars. The capacity of each jar is 150 litres and they contain 150 000–200 000 eggs, which are kept in movement by means of a vertical flow. A strainer fixed to the upper part prevents the eggs from being carried away. This method is used for larvae production on a smaller scale. The 'October' Production Brigade (district of Xishui, Hubei) has this type of hatchery (15 jars, 200 litres each) and produces 8 million larvae per year in this way (Figure 18).

After hatching, the larvae are usually kept in the incubator until their sac has been formed and even until their yolk sacs have been resorbed. They then swim freely and are collected and transferred to the nursery ponds. At 26°C, for the grass carp, this period may last 110 h, i.e., 4–5 days.

However, when the larvae are to be sold outside the farm, as happens at the Hengjiang fry-rearing centre (Guangdong), the larvae may be kept for several days in a net cage hung in the pond (Figure 20), in which some natural food is available. Eight-day old fry (6+ mm) are produced in this way and distributed (Section 13.1.1).

5.2 Nursery Rearing of Chinese Carps[1]

Nursery rearing consists of producing fry 2–3 cm in length (average 0.5 g), from larvae a few days old. Monoculture in small ponds of approximately 200 m^2 and with a water depth of 1–1.5 m[2] is used.

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[1] Subject dealt with in detail – Pagán-Font and Zinet (1980)

[2] See also multigrade farming method

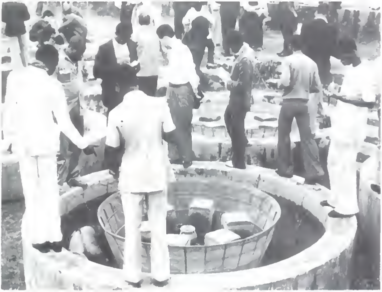

Figure 17 Round ponds for incubation and hatching of eggs. Hengjiang fry-rearing centre, Guangdong

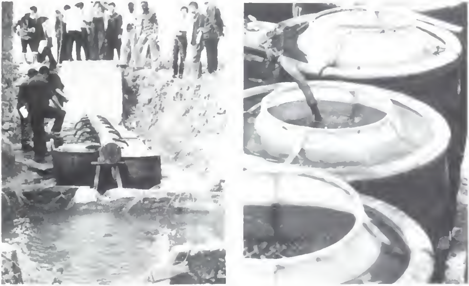

Figure 18 Rustic hatchery with terracotta incubation jars. Details of the upper strainer and water supply. 'October' Production Brigade. District of Xishui, Hubei

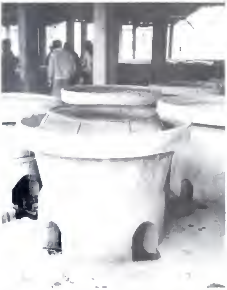

Figure 19 Cement incubation jar. Capacity 500 litres and 800 000-1 million eggs. Fish Culture Centre of the district of Qingpu, Shanghai

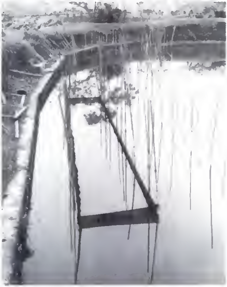

Figure 20 Cage for stocking young fry prior to transport. Hengjiang fry-rearing centre, Guangdong

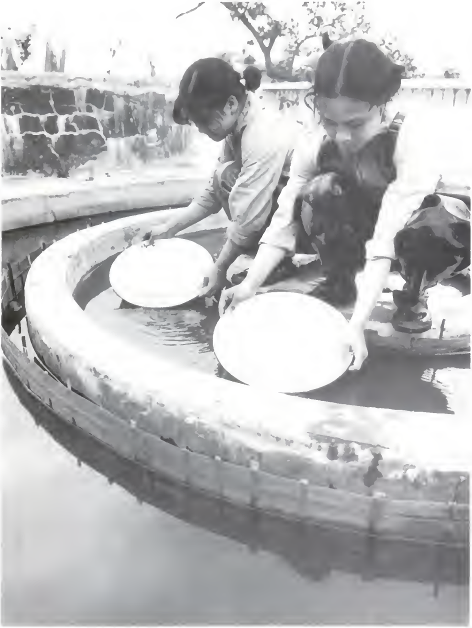

Figure 21 Examining eggs which are being incubated in a two-compartment round pond (Photo F. Botts)

Prior to stocking, the pond is cleaned, disinfected (Section 6.6.4) and fertilized. Fertilization is considered very important for the future success of the rearing operation. It combines an application of 'tatsao' (a mixture of several tender and easily decayed herbaceous plants), compost (1:1 mixture of vegetable matter and organic fertilizer with 1 percent quicklime, used after decay), and mineral fertilizer (ammonium sulphate or urea and calcium super-phosphate). The purpose of fertilizing is to promote adequate development of the planktonic organisms preferred by the young fry of the Chinese carp species, reared in ponds. Indeed, this feed preference varies depending on the species and changes gradually during the nursery stage (Table 6).

The colour of the water indicates the degree of fertility of the pond. It must preferably be a brownish-green to greenish brown. Young bighead carps are also used for this purpose (2 250-3 000 specimens, 20 cm long/ha). Fertilization is adequate when the carps do not surface too often early in the morning. These bighead carps also feed on macrozooplankton (e.g., cladocera), which are not favourable to the growth of the young fry. They are removed from the pond before stocking of nursery fry takes place.

The stocking rate of a nursery fry pond depends on its fertility, depth and local climatic conditions, feeding, etc. Generally speaking, the rate for grass carps, bighead and silver carps is 150-225 fry/m², and for mud carps, 450-600 fry/m².

Feeding during rearing varies according to the species and the region. It may be based on regular applications of tatsao, with or without supplementary feeding. This may consist of groundnut cakes, maize flour or rice bran (Guangdong) and a soya cake or coconut based paste. The daily ration varies between 1 and 4 percent of the biomass present.

During the nursery stage, average fry growth is between 0.01 and 0.02 g/day. It varies according to age and species. For fry under 6-8 days old, the daily rate of growth is highest for the grass carp. It is slightly less for the bighead and silver carps. However, over the age of 6-8 days, the species are classified from this point of view in reverse order (silver carp > bighead carp > grass carp) until the age of about 30 days.

The fry reach 2-3 cm in less than a month. At the Leliu People's Commune, nursery rearing takes 25-30 days; at the Baitan Hu State Farm, only 15 days are required (feeding with soy bean milk), and in the Shanghai area, it is 20-25 days. Mortality reaches 20-40 percent during this period. It is relatively lower for the grass carp.

Prior to the young fry being transferred to other ponds, they are strengthened physically. This is done by raising the net two or three times and by getting them used to high densities in cage nets (Figures 22 and 23). Finally, they are collected, sorted according to size and stocked to await their transfer (Figures 24, 25 and 26).

5.3 Fingerling-Rearing in Ponds[1]

This consists of producing stocking fry which will become food-fish. The young 2-3 cm-long fry grow to a size of between 12 and 30 cm, except for the mud carp (6-8 cm)[2]. This second stage of the rearing process varies from region to region, depending on the final size to be reached. At the Leliu People's Commune (Guangdong), it is broken down into three distinct periods:

- (II A) sizes increase from 3+ cm to an average of 6 cm in 30 days;
- (II B) from 6 to 10 cm in 30 days, and
- (II C) from 10 to 20 cm in 40 days, which enables fingerlings of the desired size to be produced in 100 days.

However, at the Baitan Hu State Farm (Hubei), 16 cm-long fingerlings are produced in 150 days.

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[1] See Pagán-Font and Zinet (1980)

[2] Also see the multigrade rearing method (Section 6.1.4)

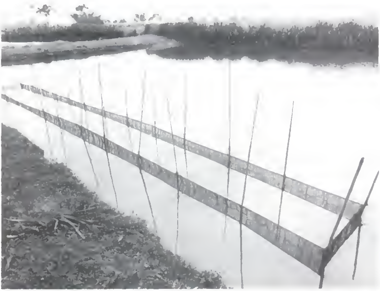

Figure 22 Catching and holding pen placed in fry-rearing pond (Photo F. Botts)

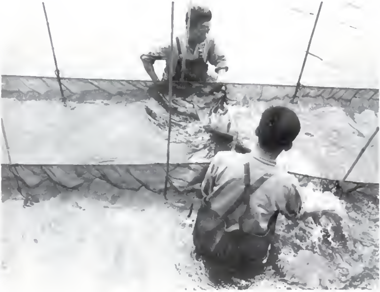

Figure 23 The fry are gathered in the holding pen with a seine net. They are 'trained' either before being transferred at the end of the first rearing stage, or monthly during the second stage (Photo F. Botts)

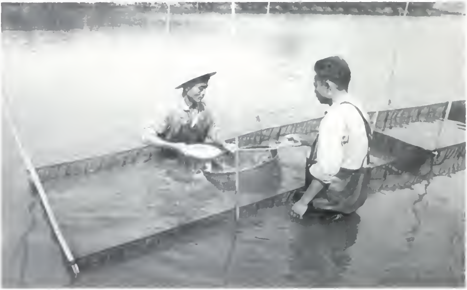

Figure 24 The fry are sorted according to size, by using bamboo woven baskets (Photo F. Botts)

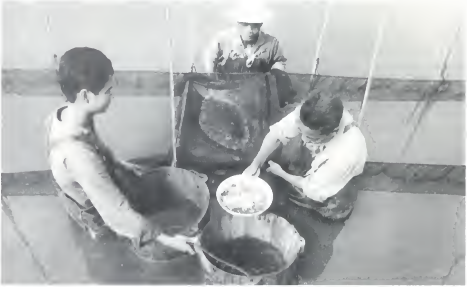

Figure 25 When they have been sorted and counted, the fry are transferred to the fingerling ponds (Photo F. Botts)

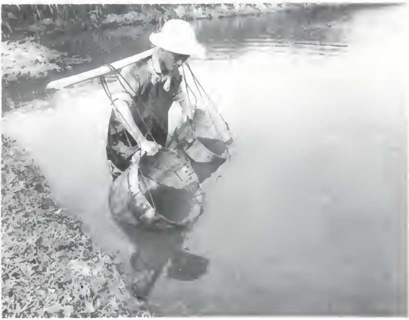

Figure 26 Fry being tipped into the fingerling pond (Photo F. Botts)

Fingerling ponds resemble fry ponds. After draining, the latter are often used to produce fingerlings. Before being stocked, the ponds selected are cleaned, disinfected and fertilized as are nursery ponds (Section 5.2).

Either the monoculture system or polyculture of two or three species may be used. Monoculture is usually preferred to produce 6 cm fry. Over and above that size, however, higher stocking rates and shorter rearing periods are possible with monoculture. It is therefore preferred to polyculture if the rate of utilization of the available ponds has to be increased, i.e., to meet increased demand for stocking fry. With polyculture, on the other hand, more complete use is made of natural food. Since it is a longer process, it can also be used to retard production of large fingerling until the suitable season (i.e., until the following spring for fingerling stocked after July). Depending on the circumstances, a combination of both types of culture is successfully practised in fish farms in China.

Stocking rates vary considerably for similar reasons. By way of example, Tables 19 and 20 show some possibilities using monoculture and polyculture, respectively (Anon., 1980). As regards polyculture, the different species (maximum three) are chosen on the basis of their dietary requirements (Table 6). The grass carp can be reared in combination with either silver, bighead or mud carps or with bighead and mud carps, because their diets complement each other. Bighead and silver carps are not often reared together, because there would be a certain degree of competition for the natural food in the pond.

During rearing, there must be regular distributions of supplementary feed. Depending on local conditions, this may include aquatic plants (e.g., *Wolffia* sp., *Lemna minor*, *Vallisneria* sp., *Hydrilla* sp., *Potamogeton* sp.), and young land plants (for grass carps), as well as the by-products of plant crops (e.g., cakes and various brans, wine, sugar and soya dregs) and animals (e.g., silkworm pupae, molluscs, mussels, fish meal). A high density of planktonic organisms is maintained by means of regular applications of organic fertilizer (e.g., tatsao and compost). Daily feed rations vary in accordance with the temperature of the water. They are larger with optimum temperatures (25°-32°C) and proportionally smaller when conditions are not as good (cooler temperatures, dissolved oxygen deficiency).

During rearing, management tasks consist of supervising the ponds and the quality of water, feeding and fertilizing, sterilizing the troughs, disease prevention/treatment and predator control. In addition, every month, the fry are gathered in a seine net. This strengthens them physically and at the same time, they are sorted and the weaker among them transferred to another pond (Figures 22 to 26). Special attention is paid to the wintering of mud carps, which are more vulnerable to low temperatures.

Table 19

Monocultural fingerling-rearing in ponds, Guangdong province
(Adapted from Anon., 1980, page 63)

Species of Chinese carp	Stocking		Duration of rearing process days	Size at harvesting (cm)
	Size (cm)	Rate individual/m^2		
Grass	3.0	30	20	4.8
	4.8	6	20	6.0
	4.8	7.5-9.0	120-150 (Sept.-Jan.)	9-12
Silver	3.0	30	20-50	6-9.5
	6-9.5	1.2-1.5	30-40	12-20
	3.0	45	120-180 (July-Nov. or Jan.)	8-8.5
Bighead	3	22-30	30	6
	6	6-9	30	12
	3	24	120-180 (July-Nov. or Jan.)	9
Mud	3.0	41	30	5.8
	5.8	13.5	50	7.5
	3.0	67.5	260-280 (July-April)	7-7.5
	3.0	180	280-300 (May-March)	4-6

The mortality rate in fingerling ponds is fairly high, although it declines as the fingerlings grow. For the grass carp, it may be 20% (3-4.8 cm), 15-20% (4.8-8 cm) and 10% (8-16 cm), i.e., a total mortality of 45-50% (3-16 cm). It may even be slightly higher when the young fry have to winter through to spring stocking.

Rate of growth varies depending on the species considered. Average rates are as follows (in g/day): bighead carp 6.3; grass carp 6.2; silver carp 4.2; mud carp 0.1 (Anon., 1980).

An original method for producing bighead and silver carp stocking fry was developed at the Baitan Hu State Farm (Hubei). Every year before May, a long-stemmed, early variety of rice is planted out in the ponds, which will be used for raising fingerlings of these two species (Figure 27). Around 10 July, the rice is about 1 m high and the grains, which are well formed, still have a milky consistency. The wild fish are got rid of with insecticide and the rice is immersed. The pond is fertilized and stocked with fry of an average length of 6 cm. Until 15 September, these fry feed on plankton and grains of rice and some supplementary feed is distributed until harvest time. This takes place in mid-November, after approximately four months of rearing and when the fingerling have reached 17 cm. This method results in a saving of 200 kg of soy bean cake per 10 000 fry, the cost price of which is thus cut by almost 50%. The only danger lies in a possible dissolved oxygen deficiency caused by rotting rice culms. A close watch must therefore be kept on the water of the ponds and if necessary, paddle aerators must be used during critical periods.

Table 20

Fingerling-rearing by polyculture in ponds, Guangdong province
(Adapted from Anon., 1980, page 64)

Species of Chinese carp	Stocking		Duration of rearing process (days)	Size at harvesting (cm)
	Size (cm)	Rate individual/m²		
Grass	8.0	4.5	190–210 (early July to Jan.)	12–16
Bighead	4.5	22.5		7.8–8.5
Grass	8.0	5.4	175–195 (mid July to Jan.)	12–16
Bighead	4.5	3		14–20
Grass	6	7.5	190–210 (early July to Jan.)	9–12
Silver	5	37.5		8–9
Grass	8	5.4	175–195 (mid July to Jan.)	16–20
Silver	5	4.5		20
Grass	4.8	4.5	250–270 (early July to March)	9–10
Mud	3.0	105–150		3.9–5.8

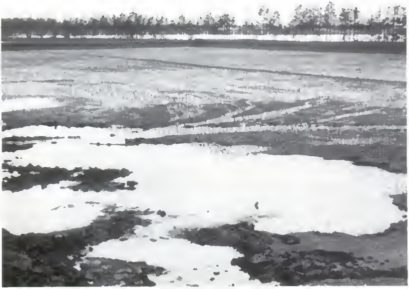

Figure 27 Intermediate rice cultivation on the bed of the fingerling pond. Baitan Hu State Farm (Hubei)

5.4 Fingerling-Rearing in Floating Cages

The study group had the opportunity of observing stocking fry production in floating cages placed either in reservoirs (Bailianhe, Hubei and Qingshan, Zhejiang - Table 35), or in the navigable channels of the Shaoxing district, Zhejiang. The three mehtods are compared in Table 21 which gives the main features of each.

In the reservoirs (Figure 28), stocking fry are produced either for other floating cages (10-13 cm, 20-25 g), or for extensive fish culture in the reservoir itself (200 g). The fry produced in the channels are also relatively large (150 g) and are used for stocking the sections of the navigable channels that have been prepared for the purpose (Section 8.2). This system which was successfully experimented in 1978 (10 cages, i.e., 660 m^2) and in 1979 (222 cages, i.e., 14 652 m^2), was to reach pilot scale in 1980 with the use of higher stocking rates.

5.5 Fingerling-Rearing in Pens

Fry for stocking the Qingshan Reservoir (Zhejiang) are produced in a fish pen (Figure 30). This consists of a bay of approximately 1.6 ha, closed by a net barrier. The lower part of the net is held against the bottom by means of a chain and blocks of concrete. The upper part is attached to floating pontoons and emerges from the water to a height of 0.8 m. This net has a 7.5 mm mesh. The depth of the water varies with the season and can reach a maximum of 6 m.

In spring each year, the pen is stocked with bighead and silver carp fingerlings of an average size of 13 cm/20-25 g, at a rate of 150 000-225 000/ha. After 250 days of rearing, including a winter season, the pen contains a per hectare average of 125 000-190 000 fingerlings, each weighing 200-250 g. The barrier is then opened and these fish escape to the reservoir itself.

Management in this case consists of maintaining the barrier (adjusting height, cleaning the first metre under water once a week), organic fertilization and supplementary feeding (rice bran and soy bean cake).

Starting with a stock of 3 750 kg/ha, the yield was 35 500 kg/ha, which represents a production of approximately 31 800 kg/ha. This is a very productive method which deserves to be more widely used.

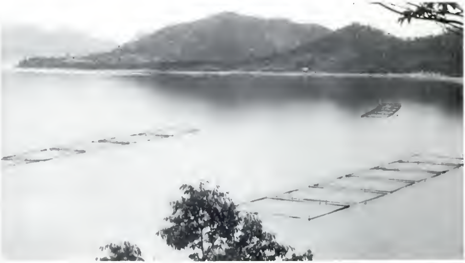

Figure 28 Series of floating cages for the production of stocking fry. Qingshan Reservoir, Zhejiang

Table 21

Some examples of polyculture-rearing of fingerlings in floating cages

Place	Bailianhe Reservoir, Hubei	Qingshan Hangzhou Reservoir, Zhejiang	Navigable channels; district of Shaoxing, Zhejiang
1. Rearing cages	- floating cages - 28-32 m^2 x 2 m = 56-64 m^3	- floating cages - 100-169 m^2 x 2 m = 200-338 m^3	- fixed cages - 66 m^2 x 2 m = 132 m^3
2. Stocking			
Size/unit weight	3 cm/0.5 g	10-13 cm/20-25 g	10-15 cm/15 g
Density, indiv./m^2	300-450	120	25-40
Rate, kg/m^3	0.075-0.115	1.5	0.18-0.30
Species used for polyculture	silver carp 85% bighead carp 10% grass and black carp 4% Wuchang bream 1%	silver carp bighead carp grass carp (few)	silver carp 70% bighead carp 5% grass carp 10% Wuchang bream 15%
3. Feeding	natural	natural (+ supplement if plankton insufficient)	wine dregs, cakes, soy beans, rice bran
4. Mortality	25-35% (escape, injuries)	10% for silver and bighead carps; 30-40% for grass carp	maximum 20% for silver and bighead carps; enteritis in the grass carp
5. Rearing time	2 months	about 8 months	7-8 months
6. Yield			
Size/unit weight	13 cm/25 g	25 cm/200 g	25 cm/200 g
Density, indiv./m^2	225-300	90-100	20-35
Rate, kg/m^3	2.8-3.8	9-10	2.0-3.5
7. Production			
Total kg/m^3	2.7-3.7	7.5-8.5	1.8-3.2
Monthly average kg/m^3	1.35-1.85	0.94-1.06	0.26-0.46

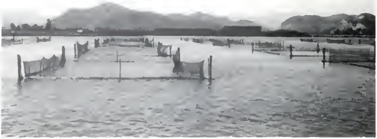

Figure 29 Series of fixed cages for the production of stocking fry. Navigable channels of the Shaoxing district, Zhejiang

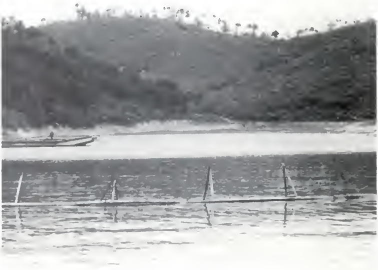

Figure 30 Fingerling-rearing in pens, in a bay of the Qingshan Reservoir, Zhejiang. View of the bay and the fence

6. SEMI-INTENSIVE FOOD-FISH PRODUCTION IN PONDS

In China, production of food-fish weighing between 0.5 and 1.5 kg, is traditionally carried out using fingerlings which have been raised in a fattening pond for several months. Depending on the temperature and fertility of the waters of the region under consideration, the complete production cycle (from egg to table fish) takes 2-3 years. It may exceptionally take one year in the hottest and most fertile southern regions.

The most widely used farming system is polyculture, using complementary species, organic fertilizing of the waters and supplementary feeding. This is why it is defined as 'semi-intensive', by opposition to the intensive system based essentially on artificial feeding of fish reared in ponds (Section 7) and the extensive system which is based on natural feeding (Sections 8, 9 and 10).

Not only is this system well-suited to the species used, but it also fits in with the current policy of integrated development of plant and animal production and self-sufficiency in food, which is being pursued in the rural areas of China. Historically, the fundamental principles of management of this semi-intensive system have been known since the Fifteenth Century (Table 10), but it is only recently, since 1960, that it has been possible to apply them on a large scale (Section 2.6).

6.1 Polyculture of Chinese Fish Species in Ponds

6.1.1 Principles of Chinese polyculture

Polyculture of Chinese fish species rests on three principles:

(a) complete use of the pond, both in depth, from the surface to the benthic zone and over its entire surface area;

(b) complete use of all types of natural food present in the pond: phyto- and zooplankton, benthos, aufwuchs, detritus, aquatic plants, and

(c) taking advantage of mutual benefits while avoiding competition for food. Several different species are therefore reared together in the fattening pond. Depending on the type of food available locally, one or two of the main species of Chinese carps are chosen: silver, bighead, grass, black or mud. They are then combined with complementary secondary species on the basis of the principles set out above and the ecological requirements of the species considered (Table 17), e.g.:

  (i) since the droppings of the grass carp are rich in undigested plant fibres, they help the development of plankton which feeds silver and bighead carps[1];

  (ii) to control molluscs, 75-100 black carps/ha are added to the pond, while, to control small fish and red shrimp, 450-600 carnivorous fish may be added, if the pond is drained annually;

  (iii) the common carp scours the bottom of the pond to obtain its nourishment and this helps aerate the sediment, oxidize organic matter, recycle minerals and finally encourages the development of plankton and the growth of plankton-feeding species, and

  (iv) nevertheless, competition may develop between the common carp and the mud carp, the silver and bighead carps, or the silver and mud carps, which makes it necessary to limit the number of one or the other of these species (common carp: 150-225 kg/ha; silver carp: 300-450 kg/ha).

During the study tour, several examples of polyculture were able to be identified in addition to those mentioned in the literature (Table 22). They are a good illustration of how fish combinations vary according to region. The mud carp is confined to a hot subtropical climate, while there are more black mollusc-feeding carps as we approach the lakes, i.e., in the Jiangsu province. The total number of species used in polyculture generally varies between four and eight, although the current trend is to increase the number.

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[1] According to a Chinese proverb: "If you feed a grass carp well, you can feed three other fish at the same time"

Table 22

Fish combinations used in polyculture
(tN = total number of fish; tW = total weight of fish)

Fish species	Guangdong		Hunan		Hubei	Jiangsu	
	Leliu People's Commune % tN	Delta % tW	Linfu State Farm % tW	Shihu PC % tW	Baitanhu State Farm % tW	Hele PC % tW	Holi PC % tW
Silver carp	3.5	7.8	45	58.6	60	30.7	38.5
Bighead carp	5.8	47.3	20	17.8	15	9.5	7.0
Grass carp	9.3	18.8	20	11.3	20	28.4	19.6
Mud carp	81.4	18.8	-	-	-	-	-
Black carp	-	1.6	-	-	-	12.4	20.0
Common carp	-	1.6	5	3.5	3	3.0	5.0
Wuchang bream	-	1.0	-	-	-	10.0	8.5
Crucian carp	-	-	-	-	2	2.0	0.6
Tilapia	-	3.1	-	-	-	4.0	0.8
Miscellaneous	-	-	10	8.8	-	-	-
Reference	pers. comm.	Anon., 1980	ADCP, 1979		pers. comm.	pers. comm.	ADCP, 1979

6.1.2 Stocking rate and density in polyculture

Ideally, we consider that the total stocking rate in a fattening pond under natural conditions should never exceed 6 000-6 750 kg/ha, so that the rates of dissolved oxygen may be sufficiently high and to ensure adequate rates of growth (Anon., 1980).

Where the four family carps are concerned, there are also specific stocking rates which should not be exceeded in polyculture (Table 23).

Table 23

Maximum specific stocking rates in polyculture
(adapted from Anon., 1980)

Species of Chinese carp	Initial maximum stocking rate (kg/ha)	Final maximum stocking rate (kg/ha)
Mud	660-1 200	1 875-2 400
Grass	480-750	1 350-1 500
Bighead	150-300	450-600
Silver	105-195	300-450

The initial stocking density of the pond, expressed in number of individuals of each species per unit of surface, is calculated by dividing the final maximum stocking rate per species by the final unit size required for marketing. This size varies according to the region and the species. In the province of Guangdong, for example, the silver, bighead and grass carps are sold when they reach a size of 1-1.5 kg, while in the province of

Hubei, a size of 0.5-1 kg suffices. On the other hand, mud carps are eaten at 125-250 g. Therefore, if we wish to produce bighead carps each weighing 1 kg, stocking density should not exceed 600 kg/ha divided by 1 kg, i.e., 600 individuals/ha. This density may be doubled if the final size of the fish is reduced to 0.5 kg. We could also allow for the rate of mortality expected during rearing (e.g., 5 percent) and thus correct the stocking density calculated above accordingly.

6.1.3 Traditional polyculture: separate age method

Traditionally, Chinese carps for consumption are produced from fingerlings which have been reared in separate age groups, by polyculture (separate age method). The complete rearing cycle in ponds therefore comprises three successive stages, two fry/fingerling raising stages (Section 5) and one fattening stage. During the latter stage, fry of the same age class, of the species chosen, are raised together in the same pond.

One to three of these species are considered the main species and the others, secondary. The species to be farmed are chosen according to the principles of polyculture (Section 6.1.1), but also according to:

(i) geographic location and the fry available;
(ii) the food to be used, and
(iii) fertility of the ponds.

Therefore:

- abundant plant matter: grass carps and various Chinese bream
- abundant organic fertilizer: silver, bighead and mud carps, and tilapia
- fertile ponds: silver and bighead carps
- infertile ponds: grass carps
- use of domestic wastes: mud carps and tilapia

In sub-tropical zones the main species are usually bighead, mud and grass carps. A practical example of this type of fish farming can be seen in the Zhu Jiang delta region, Guangdong (Table 24).

6.1.4 Improved polyculture: multiple age and multigrade methods

The traditional method has been improved in recent years. At the present time, two main types of improved polyculture are practised:

(a) using mixed aged classes (the multiple age method), and
(b) using separate age classes (the multigrade method).

(a) The chief aim of improved polyculture using mixed age classes (locally termed 'rotational harvesting and stocking') is to maintain the specific stocking rates at their optimum level throughout the rearing period. To achieve this, a sufficient number of fingerlings of the chosen species and from different age classes are intially stocked in the growing pond. After a few months of growth, the specimens which have reached marketable size are harvested and replaced by other fingerlings. The frequency with which harvesting and stocking takes place differs according to species, initial sizes, marketable sizes, feed distribution, etc. Generally speaking however, this method allows one or two harvests to be carried out annually for mud, common and black carps (species which exhibit slow growth), two harvests for grass and silver carps and up to five or six for bighead carps. This is why the multiple age method has developed so rapidly.

Two examples of this method were seen during the visit to the 'October' Production Brigade, district of Xishui (Hubei). Two ponds have been set up in a former river bed and polyculture is practised using seven species, with the grass carp as the main one. Large fingerlings (grass carps 500 g and others 100 g each) are stocked twice a year, in January and July. The more fertile of the two ponds (0.47 ha), which is stocked at a high density of 8 300 fingerling/ha/stocking operation, well fertilized and supplied with food (aquatic grasses), produced two harvests totalling 7 450 kg/ha in 1979. The second pond (4 ha), which was stocked only twice at the rate of 3 225 fingerlings/ha each time, produced two harvests totalling 4 100 kg/ha of food-fish during the same year.

Table 24

Traditional polyculture by separate age classes, in the region of the Zhu Jiang Delta, Guangdong
(adapted from Anon., 1980, page 84)

Species	Stocking				Harvest			Mortality (%)	Production	
	Size (g)	Denaity specimens/ha	Stocking rate kg/ha	% tW	Size (g)	Density specimens/ha	Stocking rate kg/ha		kg/ha	total %
Bighead carp	500	2 250	1 125	47.0	1 000-1 500	2 175	2 715	3.3	1 590	27.2
Mud carp	25-50	14 000	450	18.8	120-160	13 050	1 958	6.8	1 508	25.8
Grass carp	250	1 800	450	18.8	1 000-1 500	1 440	1 815	20	1 365	23.3
Silver carp	250	750	187	7.8	1 000	705	705	6	517.0	8.8
Tilapia	15-20	4 000	75	3.1	150	3 750	562.5	6.2	487.5	8.3
Common carp	100	375	37.5	1.6	900	300	270	20	232.5	4.0
Black carp	500	75	37.5	1.6	2 000	60	120	20	82.5	1.4
Wuchang bream	50	525	30	1.3	250	375	97.5	28.6	67.5	1.2
Total		23 775	2 392	100		21 855	8 243	8.1	5 851	100

More detailed data is obtainable for an experimental pond (0.48 ha) in the Wuxi region, Jiangsu (ADCP, 1979), where improved polyculture by mixed age classes was already being practised at a relatively intensive level in 1977 (Table 25). Fingerling of different age classes, belonging to eight different species (mainly silver, grass and black carps) were first stocked in January. It was therefore possible to carry out a first selective harvest in June-September of grass carps (over 1 kg in weight), silver and black carps (over 500 g). Further stocking was done in May (crucian carps and tilapia), end of June (common carp) and August (silver and bighead carps), as the ponds warmed up and the carp harvest was intensified. Feed and fertilizer were applied frequently and artificial aeration of the water was often used. The final harvest took place at the end of the year, and the fish which had not reached marketable size were used for the new rearing cycle. This method therefore allowed very high densities and stocking rates to be used initially, e.g., in January, 38 595 specimens/ha, i.e., almost 5 500 kg/ha. Six to eight months later, after the first large specimens had been harvested, a large number of small fingerlings were stocked. At the end of the year, the pond had produced 16 t/ha, which corresponded to a yield of 22.8 t/ha. Later trials confirmed these results.

Table 25

Improved polyculture by mixed age classes: Holi People's Commune, near Wuxi, Jiangsu (adapted from ADCP, 1979)

Species	Stocking					Total harvest (kg/ha)	Production	
	Month	Average weight[a] (g)	Density (specimens/ha)[a]	Rate (kg/ha)[a]	% tW		kg/ha	total %
Silver carp	Jan. Jan. Aug.	215 380 130	2 655 2 685 7 020	(2 504) 2 957[b]	38.6	7 615[b]	4 658[b]	28.5[b]
Bighead carp	Jan. Jan. Aug.	110 400 (2)	885 885 945	(453)	6.9			
Black carp	Jan. Jan. Jan.	1 070 261 18	900 915 4 875	1 303	20.0	3 340	2 037	12.5
Grass carp	Jan. Jan. Jan.	940 315 7	945 1 125 6 375	1 284	19.6	3 353	2 069	12.7
Common carp	Jan. June	185 (2)	1 770 1 770	331	5.0	1 849	1 518	9.3
Wuchang bream	Jan. Jan.	46 17	10 410 4 170	553	8.5	2 750	2 197	13.5
Carassin	May	(3)	(12 500)	37.5	0.6	1 543	1 505	9.2
Tilapia	May July	4 2.5	8 850 6 255	52.1	0.8	2 383	2 331	14.3
Total	Jan.	-	38 595	5 498	-	-	-	-
	Others	-	37 340	1 020	-	-	-	-
	General	-	-	6 518	-	22 833	16 315	-

[a] Estimated figure is given in brackets

[b] Total for silver and bighead carps

(b) Improved polyculture using separate age classes (locally termed 'multigrade conveyor culture') is a more recent technique which is less widely used than the former. It is particularly popular in the Xi/Zhu Jiang (Guangdong), where it has developed alongside efforts in collective agricultural production (Anon., 1980). It is derived directly from the traditional separate age method, but instead of being limited to two separate rearing periods, four periods are used (multigrade method) which makes it possible for larger fingerlings to be stocked in the growing ponds. The basic principles of polyculture are applied (Section 6.1.1), as well as the principles for determining the maximum stocking rates and densities (Section 6.1.2). The rearing period is shortened, the number of harvests increased and fish of the required marketable size are more easily produced. The disadvantage of this method is that a large number of ponds are required for large-scale fish production. To ensure the success of this improved system of polyculture, it is essential that production stoppages caused by a shortage of any category of fry or fingerling be avoided. The surface areas of the ponds used must therefore be sub-divided according to the needs for growth (generally 65 percent of the total area) and the needs of fry of different sizes (35 percent) which will finally be used to stock the fattening ponds. The multigrade method varies depending on the species reared. As an example, the management plans for three of the main chinese carp species are shown diagramatically in Table 26.

Table 26

Examples of management plans for Chinese carp rearing, using multigrade polyculture
(adapted from Anon., 1980)

Parameter	Storage ponds	Fry and fingerling ponds			Fattening ponds
		I	II	III	
A. Bighead carp					
Initial average weight (g)	10	10-30	40-90	200-250	500
Final average weight (g)	10-30	40-90	200-250	500	1 000-1 500
Stocking density/ha	75 000-90 000	6 000	2 400	1 050	330
Period (days)	continuous	40	40	40	40
Surface, % total[a]	1.5	3.6	8.9	20.5	65
B. Grass carp					
Initial average weight (g)	0.2	7-12	30-70	100-150	250-500
Final average weight (g)	7-12	30-70	100-150	250-500	1 300-1 500
Stocking density/ha	105 000-120 000	15 000-19 500	6 000-7 500	2 250-3 750	600-1 200
Period (days)	continuous	120-180	120-180	120-180	120-180
Surface, % total[a]	1.5	4	9	20	65
C. Silver carp					
Initial average weight (g)	1	10	40-60		250-600
Final average weight (g)	10	40-60	250-600		1 000-1 500
Stocking density/ha	60 000-75 000	3 000-4 500	300-510		300-600
Period (days)	continuous	60-90	120-180		120-180
Surface, % total[a]	0.5[b]	4	40.5		55

[a] 0.5 percent of the total surface is used for storing silver carp fry

[b] In addition to storage surfaces provided for other species

It will be seen that the storage ponds are by definition fry or fingerling ponds (Sections 5.2 and 5.3) (e.g., grass carp) or ponds for early or advanced fingerlings (silver and bighead carps, respectively). When the whole production cycle takes place locally, fry needed for stocking the storage ponds must be produced separately, in other ponds.

6.1.5 Growth rates and yields in ponds

Growth rates and yields vary widely depending on the species, the system of farming used and the region. In hot, sub-tropical conditions, with semi-intensive farming, the sizes obtained at the end of the first three years for the three main Chinese carps (Table 27) vary between 1 and 2 kg; 2 and 5 kg, and 4 and 11 kg, respectively. The best growth rate, which can reach an average of 15 g/day, is exhibited by the bighead carp. Grass and silver carps grow more slowly (6-7 g/day). When provided with a mollusc-rich diet, the black carp can also quickly grow to a large size. The mud carp however, grows slowly and is always small.

In more temperate regions, growth rates are not as high. In Shanghai, for example, silver and bighead carps reach 0.5 kg only in the second year, while grass and black carps reach 2.5 kg in the third year. At the Baitan Hu State Farm (Hubei), the main Chinese carps stocked as fingerlings (17 cm) in January-February, reach 0.5-1 kg by the end of the year. Even in temperate regions, however, growth can be relatively fast when the system of farming is intensified (Table 25).

The average annual yield from pond farming at the national level was approximately 2 750 kg/ha in 1979 (Table 8). On the basis of yields observed during the study tour (Table 28), this figure seems rather low. In order to increase yields, current trends include increasing the number of species reared by polyculture, increasing the individual size of the stocking fry, increasing stocking rates and densities, as well as intensifying management, particularly by supplementary feeding and artificial aeration. It has already been shown that in these conditions very high yields and levels of production can be obtained. At the Hele People's Commune, for example, yields approaching 15 t/ha and productions of 12 t/ha were obtained in some ponds in 1979. Production figures continue to vary widely however, and yields are closely related to the experience of the management staff.

Table 27

Growth rates for main Chinese carp species reared in ponds in hot sub-tropical climates

Species	Normal size (kg) reached at the age of		
	1 year	2 years	3 years
Silver carp	1	2-3	4-5
Grass carp	1-2	4-5	10
Bighead carp	1-2	3-4	8-11
Mud carp	(25-50 g)	(120-160 g)	(250-300 g)

Table 28

Average yield obtained in fattening ponds in 1979

Location	Pond farming a/		1979 yield	
	Area (ha)	Harvest (t)	Average (kg/ha)	Extreme (kg/ha)
1. Beijing, Shuangqiao People's Commune	80	110	3 000	max. 10 500
2. Hubei, district of Xishui, 'October' Production Brigade	11.77	92.3	6 000	4 000-8 000
3. Jiangsu, Hele People's Commune, Production Team No. 1	15.87	150	9 000+	6 000-12 000
4. Guangdong, Leliu People's Commune	2 400	7 700	3 200	1 500-7 500

a/ The farming area may sometimes include the area used for fry production, while the harvest figure refers only to table fish

6.2 Fertilization and Feeding in Fish Ponds

6.2.1 Qualitative aspects of water fertilization

Both mineral and organic fertilizers are used in Chinese fish culture. However, the latter are by far the most commonly used since they favour the development of plant and animal organisms (plankton, benthos, aufwuchs), on which the diets of the microphagic Chinese carps are based.

As regards mineral fertilizers, compound formulae are preferred and in particular, 4N-4P-2K, which is applied at the respective rates of 0.9-0.9-0.45 ppm (Anon., 1980).

The organic fertilizers consist mainly of green manures (tatsao), compost, animal manure and domestic waste water. Direct organic fertilization (e.g., piggeries and latrines on the water), although still used in some southern regions, is currently being replaced in many regions by controlled fertilization, based on prior fermentation. Farm animal droppings, mixed with plant matter and silt, ferment for ten days before being applied to the ponds. This considerably reduces the chances of pathogenic agents being transferred. Human waste matter ferments for four weeks in a closed chamber before being used.

Large quantities of these organic fertilizers are applied (Section 6.2.3) and deoxygenation of the water may result. At the beginning of the hot season and during the rainy season, special attention is paid to this danger, to prevent fish mortality. Reduction of fertilization, increase of freshwater supplies and artificial aeration are the principal measures taken to avoid mortality.

6.2.2 Qualitative aspects of feeding

In the semi-intensive system of fish culture, two main types of food (plants and agricultural by-products) are distributed to farm fish in addition to an increased supply of natural food resulting from fertilization of the pond. Compound feeds are still reserved on a priority basis, for intensive farming (Section 7), although they could also be used as feed supplements in the semi-intensive system.

Among the plants which are distributed mainly to the herbivorous species (forage), but which could also have a fertilizing effect (green manure) - we must mention elephant grass (*Pennisetum purpureum*), various vegetables, fresh rice stalks, leaves and stems of melon and maize and leguminous plants, as well as several aquatic plants, such as the water hyacinth (*Eichornia crassipes*), *Pistia*, *Wolffia*, *Lemna* and *Azolla*. Land plants can be cultivated on the dykes which separate the ponds (Section 6.3), especially elephant grass, whose root system protects the soil from erosion and whose quick growth allows it to be cut repeatedly (Figure 35). Large quantities of aquatic plants are cultivated in the shallow ditches, canals and ponds (Figure 33). Water hyacinths produce 400-750 t/ha of plant matter annually. They can be cut into pieces and composted/fermented together with manure and quicklime prior to being applied to the ponds.

There are also many agricultural by-products in use. Depending on the region, these are cakes (soy bean, groundnut, etc.), brans (rice, wheat, barley), cereals (maize, sorghum and barley grains), residues of fermentation (wine, beer, soya), or silkworm pupae (Figure 36).

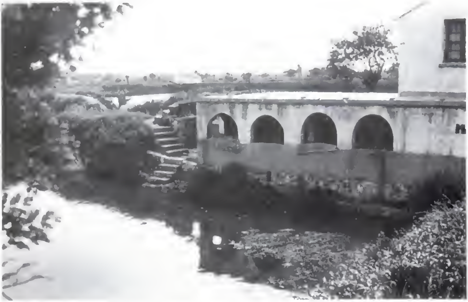

Figure 31 Piggery at the pond's edge. Hele People's Commune, Wuxi, Jiangsu

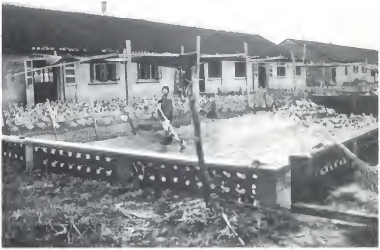

Figure 32 Duck farm from which the fertilized water is distributed among several fish ponds by means of a system of canals. Hele People's Commune, Jiangsu

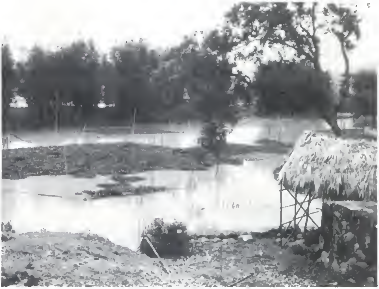

Figure 33 Cultivating *Eichornia crassipes* and *Azolla imbricata* for animal feeding. Leliu People's Commune, Guangdong

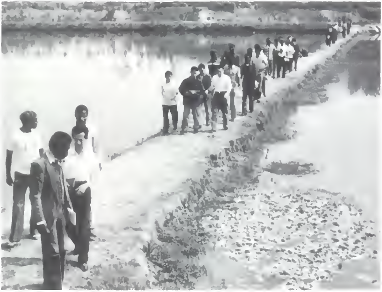

Figure 34 Feeding grass carps with residue from vegetable crops. 'October' Production Brigade, Xishui, Hubei

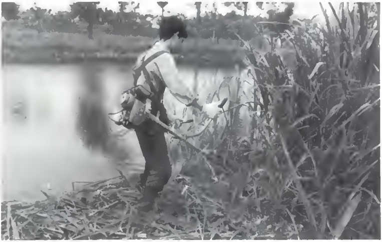

Figure 35 Cutting elephant grass cultivated on the dykes of the ponds as food for grass carp (Photo F. Botts)

Figure 36 Casting the daily ration of agricultural by-products (Photo F. Botts)

6.2.3 Quantitative aspects of fertilization and feeding

It is practically impossible to dissociate fertilization and supplementary feeding in semi-intensive Chinese aquaculture, since they together provide nourishment for the fish during both their rearing and fattening periods. Where organic fertilizers are available, they can be used in large quantities, as the few examples provided during the study tour show (Table 29). The food that is distributed serves either to complete the natural diets of the planktonivorous species, or to feed the grass and mollusc-eating species directly.

As stated above (Section 6.1.1), species for cultivation are chosen on the basis of the main types of food available locally. More widespread use of compound feeds (Section 7.1) should also give fish culturists a freer hand in the future, since grass and black carps could then be cultivated when large quantities of forage or molluscs are not available. In this context, it must be recalled that a grass carp weighing 1 kg consumes an equal quantity of plant matter daily.

The rates of transformation into fish of the various fertilizers and foods, quoted by the technicians of Hele People's Commune (Jiangsu) were as follows:

- manure: 200 kg - produce 1 kg of bighead or silver carps;
- land plants: 30-35 kg - produce 1 kg of grass carp or Wuchang bream, and
- molluscs: 22 kg - produce 1 kg of black carp

Also, the quantity of each feed supplement required to produce 1 kg of grass carp is approximately the following (Anon., 1980): young land forage - 35 kg; aquatic forage: *Wolffia* - 37 kg, *Lemna* - 40.6 kg or *Vallisneria* - 101 kg; silkworm pupae - 1.8 kg; soy bean cake - 4 kg; rice bran - 6.8 kg.

The droppings of the fish themselves may be integrated into the production cycle of other species through the action of bacteria and planktonic organisms. At the Hele Fish Culture Centre (Jiangsu), it is considered that the droppings produced by the black or common carp during the time it takes them to increase their weight by 1 kg, can produce 0.6 kg of bighead or silver carp. Another example of this type of organic recycling was observed at the Fish Culture Centre of the Qingshan Reservoir (Zhejiang), where grass carps are reared intensively in cement ponds (Section 7.2). Downstream from these ponds, silver and bighead carps are reared in a cement-lined channel, using the droppings of grass carps (Figure 37). A biomass of 100 kg of these droppings suffices for the extensive rearing of 10 kg of planktivorous carps.

Table 29

Quantities of organic fertilizer and feeds used annually for fish production in ponds

Location	Fish production	Organic manure	Plant matter	Various products
Leliu People's Commune, Guangdong	2 400 ha 7 700 t + 140 million fry	50 000 t (silkworms, pigs, etc.)	154 000 t (elephant grass)	5 400 t (soy bean cake and brans)
Hele People's Commune, Jiangsu	harvest: 11 895 kg/ha output: 8 880 kg/ha	246 t/ha	136.5 t/ha	- molluscs: 45 t/ha - agri. prod. (barley): 3 975 kg/ha
Others (Zhu De-Shan, 1980)		300-375 t/ha	105-150 t/ha[a/] (aquatic plants)	- molluscs: 75-112 t/ha - agri. prod. 1 500-2 250 kg/ha

[a/] Equivalent aquatic plant matter, calculated on the basis that 1 t of land plant matter is equal to 2 t aquatic plant matter

6.2.4 Principles of fertilization and feeding

Fertilization and feeding are used in such a way that the principle 'even, good and sufficient' may be respected. In practice, this results in the 'four fixes' method; fixed quality and quantity of feeds, fixed time and site of feeding (Zhu De-Shan, 1980).

For each pond the daily quantities of fertilizer and feed to be distributed are determined by the water temperature, the dissolved oxygen content, the amount of plankton in the water and the feeding performance of the fish. The technician therefore uses the method of the 'four observations', i.e., observation of the season, climate, water colour and fish.

Integration of fish culture with agriculture and the other forms of farming is widespread in the people's communes and State farms (Section 6.3). Not only does this enable a reasonable amount of the manure and feed required to be produced on the spot (e.g., on the dykes), but it also allows all agricultural and pond by-products and residues to be completely utilized. At the same time, the number of harvests increase (catch-crop growing, mixed cultivation, etc.), so that the fish can be fed all year round, and the secondary water surfaces are used to produce the aquatic plants required.

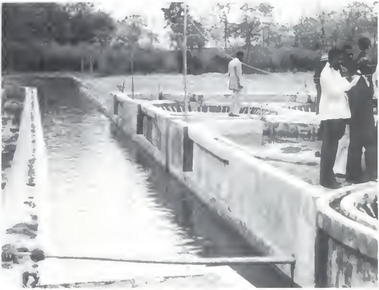

Figure 37 Cement-lined channel located downstream from farm where grass carps are reared intensively, used for integrated farming of silver and bighead carps. Qingshan Reservoir Fish Culture Centre, Zhejiang

Figure 38 Piggeries integrated with the fish culture ponds at the Hele People's Commune, Jiangsu

6.3 Aquaculture and Integrated Rural Development

Integrated rural development has been a traditional Chinese practice for many years. Encouraged by the 'total development' and 'self-sufficiency' policies, it has rapidly spread throughout the country.

Several factors were favourable to the integration of aquaculture with agriculture and other forms of livestock rearing:

(i) since the main fish species cultivated are herbivorous and planktonivorous, they can easily take advantage of the plants and organic manures produced locally;
(ii) silk production based on silkworm rearing and the planting of mulberry trees, provides residues which have a high food value for fish;
(iii) direct use of domestic waste water to fertilize ponds and cultures is a traditionally accepted practice, and
(iv) the ponds are considered possible sources of irrigation water and fertilizing silt for near-by cultures.

This policy of integrating fish culture with other types of agricultural production results in the complete utilization, not only of land and water resources, but also of by-products and residues. The benefits for the rural community are considerable:

(i) income from fish culture has increased in relation to that from other types of farming and from cereal and vegetable production;
(ii) the sources of income are diversified, which protects the community from the effects of a crop disaster;
(iii) the community becomes self-sufficient in food;
(iv) fertilizers and fish feed are mostly produced locally and are inexpensive, which cuts down on transport and the cost of fish production and at the same time, increases profits[1], and
(v) silt from the ponds enables agricultural production to be increased and purchases of more costly mineral fertilizers can therefore be reduced[2].

However, for this type of integrated aquaculture to be fully successful, farm management has to be adapted. To be able to feed the fish all through the year, the number of harvests must be increased through catch-cropping and mixed cultivation. Cultivation of aquatic plants must be developed. Specialized teams must be trained, not only in fish culture, but also in cereal, forage, vegetable, silkworm, pig and poultry production, etc. It soon became obvious that to carry out integration on a wide scale in China, the number of adequately qualified persons required to diversify production exceeded the normal possibilities of the production teams. Experience showed that management of such integrated farming operations was much more effective when in the hands of the production brigades. This is why, at the Hele People's Commune (Jiangsu), integrated farming, in addition to the management of two community fish culture centres, orchards and workshops, is in the hands of 13 production brigades (95 production teams), five for vegetable cultivation, seven for grains/mulberry trees/silkworms and one for fish culture.

Two people's communes involved in integrated fish culture were visited by the study group. They may be taken as practical examples of what is currently possible in this field: the Leliu People's Commune (Guangdong) and the Hele People's Commune (Jiangsu), the former specialized in fish culture (Table 15) and the latter not (Table 14). In both cases, certain observations were made as regards the practical side of integrating fish culture with crop and animal farming. This is shown in table form in Table 30, but may be summarized as follows:

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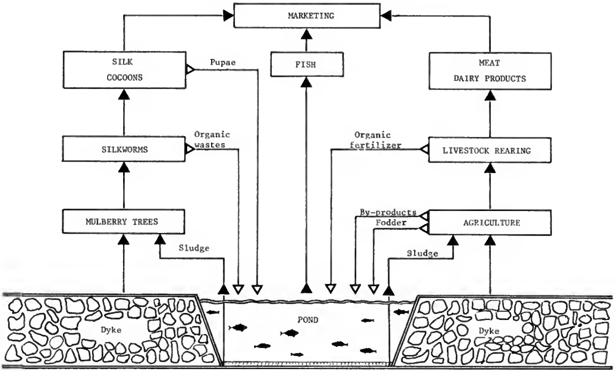
[1] It has been suggested that integration would result in a 30-40 percent increase in profits (ADCP, 1979)

[2] A third of all fertilizers used in Chinese agriculture is said to come from the ponds (ADCP, 1979)

Table 30

Integration of fish culture/agriculture/livestock farming



(a) the dykes of the ponds, the crowns of which are sometimes over 10 m wide, participate fully in the plant production cycle. The top of the dykes are planted with groundnuts, vegetables, colza, sugar cane and mulberry; the slopes are planted with maize and elephant grass, while the edges are planted with bananas and other arborescent plants (Figures 39, 40 and 41);

(b) the canals and ditches produce various aquatic plants, such as water hyacinths, duckweed, *Azolla* (Figure 33);

(c) pigstys are also set up on the dykes and in the Guangdong province, even latrines provide organic fertilizer for the ponds (Figures 31 and 38);

(d) at Hele, where duck rearing is carried out on a large scale, droppings are collected daily. A jet of water is used to move them toward the ponds (Figure 32);

(e) at Leliu, where silkworm catarpillars feed on mulberry leaves until they change into nymphs/pupae, residue from this intensive production (droppings + plant remains) are used to fertilize the ponds and feed the fish;

(f) when the ponds are drained, the silt taken from the bottom, which is rich in nitrogen (2 percent) is spread on neighbouring crops, particularly the mulberry bushes (Figure 48), and

(g) clayey soil is extracted, pressed and baked locally to produce bricks. The resulting excavation becomes a pond.

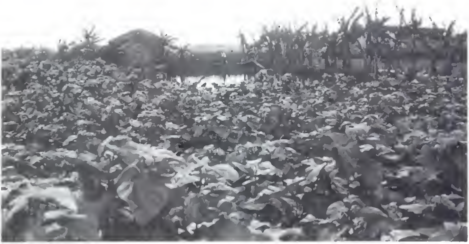


Figure 39 Integrated development at the Leliu People's Commune, Guangdong: fish ponds, piggery, bananas, mulberry, sugar cane, etc.

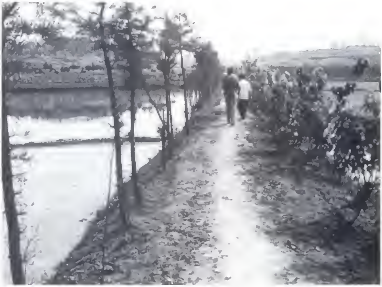


Figure 40 Use of pond dykes for the cultivation of mulberry and forest plants. 'October' Production Brigade, Xishui district, Hubei

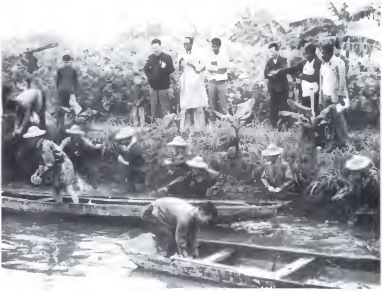


Figure 41 Different crops right up to the water's edge. Leliu People's Commune, Guangdong

One of the main reasons for success is the adequate surface area allocated to fish culture, different major crops and livestock rearing. It has been suggested thet the total surface area is broken down as follows: fish culture, 60%; livestock, 14%; fodder crops, 14%; food crops, 10% (ADCP, 1979). However, the type of crop preferred on the farm strongly influences fish yields and there too, a certain balance must be obtained. This is why, at the Leliu People's Commune (Guangdong), which specializes in fish culture, the annual yields of the ponds of the different production brigades varies between 1 500 and 7 500 kg/ha, depending on the proportion of the total area under mulberry as compared to the area under sugar cane. Fish yield is higher when this proportion is higher and when larger quantities of residue from silkworms are available for the ponds. According to the Leliu technicians, the ideal, balanced proportions should be in the vicinity of 50% for fish culture, 30%+ for sugar cane and 10%+ for mulberry.

Throughout the study tour, members obtained quantitative data from their Chinese hosts on the different types of production, as well as on the coefficients of conversion, normally used to plan the operation of fish farms, crop and livestock farming activities combined (Table 31). They have been worked out empirically efter many years of practical experience and will have to be confirmed on a scientific basis in the future.

Finally, during normal periods, a relatively small number of specialized staff is used to manage the integreted farms. An average of one person to up-keep 6-8 ponds, each 0.33-0.47 ha, or 30-50 pigs or 500-1 000 poultry. Extra personnel is used only in periods of intense activity, e.g., at harvest time, stocking time or for marketing.

Table 31

Output and coefficients of conversion used when fish culture
is integrated with crop and livestock farming

A. ANNUAL OUTPUT

(a) Plant Production

- Elephant grass (*Pennisetum*), Guangdong: 225 t/ha
- Aquatic plants: *Lemna*, *Azolla*, *Wolffia*, etc., Guangdong: 150-187 t/ha
  water hyacinth (*Eichornia*), Guangdong: 400-750 t/ha
- Sugar cane; leaves, Guangdong: 90 t/ha
- Mulberry; leaves, Guangdong: 135 kg/plant or 45 t/ha

(b) Production of Organic Fertilizers

- Pigs: 7.8-8 t/pig
  (Hele People's Commune: 6 pigs = 21 t in 5 months of piglet weighing 65 kg live weight)
- Cows: 6-9 t/cow (Hele People's Commune = 21 t/cow)
- Ducks: Hele People's Commune, Jiangsu: 150 kg/duck

(c) Silt

- Rate of accumulation at Hele People's Commune, Jiangsu: 10 cm/year
- Pond production: 125-225 t/ha

B. CONVERSION TO INTEGRATED SYSTEM

(a) Plant Cultivation

- Aquatic plants: 1 ha can feed 150 pigs
- Land plants (residue): 1 ha can feed 15 pigs

(b) Fish Culture

- Land plants: 0.1 ha can feed 1 ha of pond
- Compost: 4 kg produce 1 kg of fish
- Silkworms: 1 ha of mulberry = 45 t of leaves = silk + 150 kg of fish
  10-20 kg residue produce 1 kg of fish
- Pigs: 45-75 pigs/ha of pond (Hele People's Commune: optimum 90 pigs/ha)
- Fowls: 450 fowls/ha of pond
- Ducks: maximum 1 200-1 400 ducks/ha of pond
- Silt: 2 ha of pond allow 1 ha of crops to be fertilized

6.4 Tilapia Farming in China

Tilapia farming is relatively new to China. Indeed, *Sarotherodon mossambicus* (syn. *T. mossambica*) was introduced for the first time in Viet Nam in 1957. Another species, *S. niloticus*, was introduced only a few years ago and the current trend is for it to replace *S. mossambicus* in fish farming.

The study group had the opportunity of seeing a tilapia farm at the Hele People's Commune (Jiangsu). *S. mossambicus* was introduced only in 1971 and *S. niloticus* only in 1978, on an experimental basis. The latter will be cultivated in ponds from 1980.

Since the winters are too cold, the brood fish and fry are raised from November to May in plastic green-houses, where the pond temperature does not fall below 17-20°C (Figure 42). Two 120-m² earth ponds are stocked at the rates of 5 kg/m² (brood fish) and 500 specimens/m² (fry born in August/September). They are fed on rice bran, distributed every 2-3 days at the rate of 0.5 percent of the biomass. The brood fish spawn as soon as the water temperature reaches 20-22°C and it has been noted that a *S. mossambicus* female weighing 50 g, can produce an average of 350 fry/year.

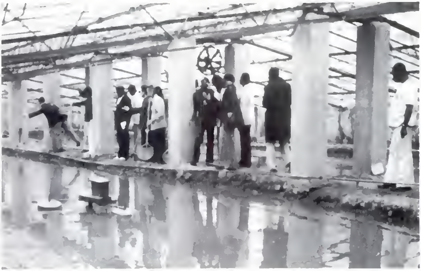


Figure 42 Tilapias wintering under glass in earth ponds equipped with floating aerators, Hele People's Commune, Wuxi, Jiangsu

From May, tilapias are reared in well-fertilized ponds as a secondary polyculture species (Table 22). The average stocking rate with 5-7 g fry is 1.5 specimens/m². They reach an average weight of between 50 and 70 g in 120 days of rearing. Three months later, females usually weigh more than 100 g and males, at least 250 g. Yields with *S. mossambicus* can reach 975-1 125 kg/ha in 4-5 months, respectively, without supplementary feeding and 1 875 kg/ha with feeding. Higher growth rates and yields should be possible with *S. niloticus*.

In the Guangdong province, polyculture of Chinese carps with *S. mossambicus* as the secondary species, is also done after sex distinction and sorting of the males (Anon., 1980). Since errors in sex distinction occur due to the small size of the fry (6-7.5 cm), all later spawning is controlled by means of predators (e.g., 450-600 snakeheads of between 3 and 3.6 cm in length/ha), which are stocked at the same time as the carps. The ponds are well fertilized. The low stocking density of male tilapias (0.3-0.45 specimens/m^2), combined with the warm climate, produces table fish of between 100 and 200 g each within 60-90 days. Since stocking takes place at the beginning of May and the end of July, two crops can be obtained in a year. Stocking density of tilapia cannot be increased without there being a risk of causing competition for food, not only with the main plankton feeders, but also with the detritus feeding mud carp.

Tilapia is sometimes cultivated as the main species in polyculture, particularly in very fertile waters which have been enriched with domestic waste water (Anon., 1980). In this case, stocking is done once a year with a mixture of big (30 g; density 0.15 specimens/m^2) and small fingerlings (1.3 g; density 2.25-3 specimens/m^2). This is followed by three harvest periods:

(i) after the first spawning season, when the big fingerlings have reached 100+ g in weight (20% of the annual harvest);
(ii) from the ninth month; selective fishing of the largest apecimens (50% of the annual harvest), and
(iii) at the end of the year (30% of the annual harvest), fish for consumption and a given quantity of fingerlings for wintering.

6.5 Fattening Pond Features

6.5.1 Fish farm design

In an attempt to promote combined fish culture/crop/livestock farming, most fish farms are designed as part of communal farming systems. Farm layout will vary depending on the relative importance of fish culture as compared to the other activities.

For example, when the people's communes specializes in fish culture, the ponds are usually grouped together in a fish culture bloc and the dykes between ponds are relatively narrow (1.5-3.5 m at the top). On the other hand, when crop farming is the main activity, the ponds are dispersed among the crops which are cultivated on the dykes.

Depending on the relative importance of the fry trade, the proportion of the total surface area of the ponds earmarked for food-fish production can vary, e.g., between 45% (Leliu People's Commune, Guangdong) and 86.4% ('October' Production Brigade, Xishui district, Hubei). At the Hele People's Commune (Jiangsu), however, the technicians consider 70% to be the optimum proportion.

Water is supplied to the ponds through the crop irrigation network in the plains of the delta and the shallow waters. The water is raised by pumping and is discharged into the irrigation canals which supply both the cultivated fields and the ponds. Whenever possible, gravity feed is used, such as downstream from the Qingshan reservoir, Zhejiang (Section 7.2).

Use of electric pumps[1/] has spread, following the substantial progress made in rural electrification and because of the low cost of electrical energy (Hele People's Commune, Jiangsu: Y 0.06/kWh. Traditional devices for pumping water (e.g., the 'dragon' wheel) are nevertheless still used in some regions

The ponds cannot usually be emptied, and here again, the electric pump is used to drain them partially or totally to allow harvesting of the fish and cleaning and disinfecting of the pond. Total drainage is done once a year at the most. Many technicians prefer to keep the water in the ponds for two or even three years.

[1/] These are usually moveable, low output (1-3 m) pumps, with a flow rate of 2-4 m^3/min

6.5.2 Construction of fish ponds

Most fish ponds are made of earth. Sandy clay is said to offer the best conditions: it is watertight; decomposition of organic matter, fixing of fertilizers and preservation of mineral salts are good; aeration of the bottom is satisfactory.

When the new ponds at the Baitan Hu State Farm (Hubei) were visited, the study group discovered the enormous opportunities that existed for manual work (Figures 43 and 44). In the two consecutive winters, 1 500 000 m³ of earth were moved manually by 4 000 persons working 200 days. An average of 1 875 m³ of earth was dug and transferred per man-day. A bloc of 72 ponds, each 1.5 ha (55 x 270 m) were prepared over 133 ha of land.

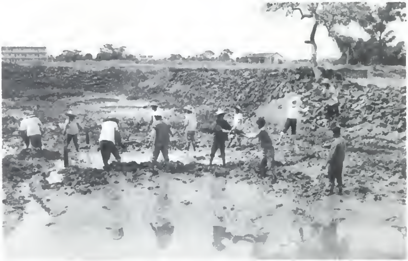


Figure 43 Manual construction of a fish pond (Photo F. Botts)

The dyke banks usually have a 1:1.5 to 1:2 slope. It may be gentle, to provide larger areas for crop cultivation. The width of the crown varies according to its use: as a pedestrian path (1.5-2 m), or for crops (10 m and over). As described in Section 6.3, the greater part of the dyke surface may be cultivated to produce the feedstruffs required for animal rearing, including fish culture.

The study group also visited cement ponds, which are used preferably for intensive fish culture (Section 7).

6.5.3 Fattening pond features

The surface areas of the growing ponds vary from 0.26 ha to more than 1 ha. However, earth ponds of 0.7 ha are preferred. Larger areas are chosen when the ground is less impermeable. The pond must be big enough to profit from the beneficial effects of the wind which mixes and oxidizes the water. On the other hand, too large ponds are difficult to manage and operate and the fish do not receive equal amounts of food (Anon., 1980).

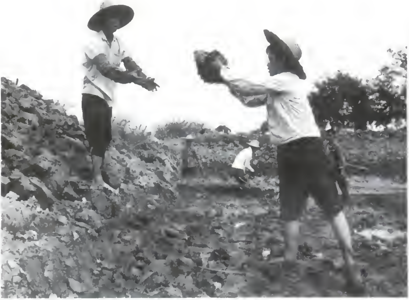


Figure 44 Manual construction of a fish pond: cutting out, transferring and placing clods of earth (Photo F. Botts)

The depth of the water varies between 2 and 3 m, which ensures relatively stable temperatures and dissolved oxygen content, while providing the vertical space for the practice of polyculture with three feed levels. In colder climates and for mud carps in particular, slightly deeper ponds may be built. Since the slope of the pond bottoms is negligible, the depth of the water is practically constant.

The preferred shape of ponds is rectangular. The ratio of length to width is either 3:2, or 2:1. Old, irregularly shaped ponds (clay brick ventures, river bed, shallow) have for the most part been re-modelled and refitted, with a view to increased production. As far as intensive rearing in cement ponds is concerned, it was pointed out that oval ponds are preferred to round onces, since they allow droppings to be cleaned out more easily (Fish Culture Centre at Qingshan Reservoir, Zhejiang).

Positioning of the ponds is also important. Length wise, they should be in a north-south position, so that the pond gets maximum sunlight (winter heating, photosynthesis/oxygenation). In some places, the direction of the prevailing winds is also taken into consideration. In this case, the length of the ponds is perpendicular to the direction of the winds in order to reduce erosion of the dykes due to too heavy waves (Hele People's Commune, Jiangsu).

6.6 Management of Fattening Ponds

6.6.1 Daily inspection of the ponds

The ponds are inspected daily and the following observations made:

(a) at dawn: depending on the way the fish surface in the pond (intensity/duration), the quality of the water is adjusted if necessary;

(b) during the morning and late afternoon: the fish are observed while feeding (particularly from the point of view of appetite); adjustment of fertilization and future feeding if necessary; therapeutic treatment of fish, and
(c) during the day: check on weeds; removal of remains of plant fertilization and feed after a certain time; adjustment of water level; plugging of leaks, checking the quality of water and improvement of the quality if necessary.

The quality of the water (mainly oxygenation) can be improved by increasing the input flow of fresh water, by fertilizing the pond to increase phytoplankton concentration, by getting rid of planktonic micro-crustaceans (solution of trichlorfon, e.g., Dipterex, 1 500 kg/ha) and cyanophycean water flowers (solution of copper sulphate, 1.5-3 kg/ha) and by precipitating organic colloids in suspension (solution of alum, 22.5-45 kg/ha). The use of mechanical surface aeration is spreading rapidly, due to intensive rural electrification, the low cost of electricity and local manufacturing of paddle aerators (Section 14.1).

6.6.2 Regular fertilization and feeding

These two activities are governed and determined by the 'four fixes' and the 'four observations' (Section 6.2.3).

6.6.3 Prevention and treatment of fish diseases

Very strict preventive measures against fish diseases are generally applied during rearing: control of weeds in the ponds, cleaning and disinfecting of ponds before stocking (see below), treatment of fry, sterilization of tools, disinfection of feeding areas.

However, certain diseases still occur. They are immediately treated according to therapeutic methods established experimentally. The main fish diseases and their treatment were briefly described to the study group when they visited the Hydrobiological Research Institute in Wuhan, Hubei (Section 4.1.3). More details are given in Chinese fish culture publications (e.g., Anon., 1980, p. 96-121).

6.6.4 Chemical treatment of ponds prior to stocking

After each complete harvest and before re-stocking, the fattening tank is cleaned (Section 6.6.5) and treated with chemicals. The main purposes of this treatment is to get rid of harmful organisms (e.g., predatory fish, frogs' eggs/tadpoles, aquatic insects, crabs, etc.), and to disinfect the pond by eliminating pathogenic organisms. The treatment is carried out either when the pond is almost completely empty or when it still contains a large amount of water (Figures 45 and 46). In the latter case, the doses take account of the depth of water. Depending on local availability, the three main products used are: quicklime, tea cakes and bleaching powder (Table 32).

Quicklime (CaO) is the most highly recommended, since it has side effects which are good for the quality of the water (Anon., 1980). Indeed, not only does it get rid of all harmful organisms (including thread-like spirogyra and young aquatic plants with superficial root systems), but also helps to:

(i) clarify the water by agglutination and precipitation of organic colloids in suspension;
(ii) fertilize the water by releasing nitrogen, phosphorus, potassium, etc., absorbed by the silt;
(iii) stabilize the pH of the water at a slightly alkaline value, which encourages plankton development and fish growth, and
(iv) increase the calcium content of the water.

Calcium is an essential nutrient for both plants and animals. In a pond which is almost empty, the limestone dose varies according to the quantity of organic silt present (Table 32).

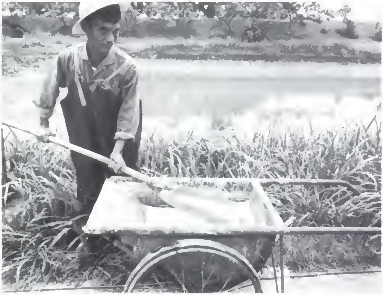


Figure 45 Applying quicklime to a small pond which has been partially drained. For large ponds, boats are used, as in Figure 46 (Photo F. Botts)

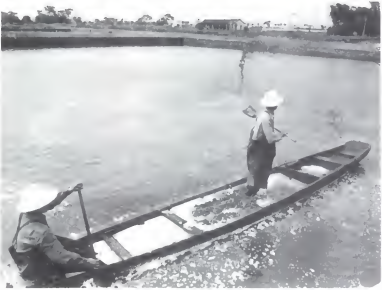


Figure 46 Treating a large pond with tea-seed cake from a boat (Photo F. Botts)

Table 32

Disinfection of fish ponds
(adapted from Anon., 1980)

Product	Treatment		
	Water in pond	Dose[a/]	Comments
1. Quicklime	6-7 cm 6-7 cm considerable quantity	750-900 kg/ha 900-1 125 kg/ha 1 875-2 250 kg/ha/m	little silt at bottom silt at bottom of pond
2. Tea-seed cakes	considerable quantity	525-675 kg/ha/m	5-10 days prior to stocking
3. Tea-seed cakes and quicklime	considerable quantity	TC: 525-675 kg/ha/m QL: 100 kg/ha/m	5-10 days prior to stocking
4. Bleaching powder	considerable quantity	203 kg/ha/m	5 days prior to stocking

[a/] kg/ha/m: kg/ha per metre of depth of water

Tea cakes are a by-product of oil production from oil-producing tea seeds, such as *Camellia (C. sasangua, C. semiserrata* and *C. deifera*). This cake contains 30 percent saponine, a deadly hemolytic toxin which, at a rate of 10 ppm, kills fish after 11 h of exposure (Anon., 1980). The higher the water temperature, the more quickly the toxic effect disappears, usually in 5-10 days. The tea-seed cake is ground up and soaked for 24 h in warm water (approximately 25°C). This solution is then diluted and distributed over the entire surface of the pond (Figure 46). Wild fish, frogs' eggs and tadpoles, small molluscs, leeches and some aquatic insects are thus got rid of.

The method usually preferred to the latter, consists of first treating the pond with tea-seed cakes (normal dose), and then applying quicklime, to improve the quality of the water (Table 32).

Bleaching powder, which contains approximately 30 percent active chlorine, has a strong oxydizing effect when mixed with water and this enables it to be used as a sterilizing agent. A solution is made up just before use and is immediately applied to the pond and distributed evenly throughout the body of water (mixing/stirring). The toxic effect is almost the same as that of quicklime, although it is less pronounced in fertile water. Toxicity disappears in five days.

6.6.5 Final harvesting of fish

At the end of the rearing period, the final harvest is done by hand, either by fishing with a seine net after having partially drained the pond, or by complete drainage (Figure 47).

6.6.6 Drying out the ponds

Complete drainage of the pond is not considered except at fairly long intervals, usually between 1 and 3 years. The beneficial effects of an annual drainage lasting 15-20 days (checking vegetation, elimination of parasites, mineralization of the bottom) are nevertheless acknowledged by the Chinese technicians. However, whether it can be done, depends essentially on local constraints imposed by combined fish culture/crop/livestock farming and the utilization of available water.

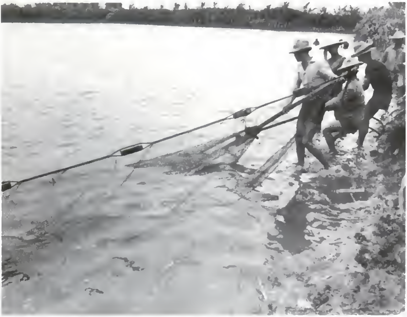


Figure 47 Harvesting fish using a seine net (Photo F. Botts)

6.6.7 Cleaning the emptied ponds

During rearing, the application of large quantities of organic fertilizers and plant feed encourages the build-up on the pond bottom of a layer of organic matter. At the Hele People's Commune (Jiangsu), the rate of build-up is approximately 10 cm per year. This silty deposit, which should not exceed 10-15 cm, helps to increase dissolved oxygen consumption and acidifies the lower levels of deep water. In order to prevent the quality of the water from being irreversibly damaged, a layer of silt is removed periodically (Figure 48) and used as organic fertilizer for crops which are cultivated in combination with fish culture (Section 6.3).

7. INTENSIVE FISH CULTURE IN PONDS

7.1 Experiments in Intensive Fish Culture

Pond production of food-fish using an intensive farming system, based on artificial feeding, is currently becoming increasingly wide-spread in China. When the study group visited the Institute of Aquatic Products of Shanghai (Section 4.1.2), this was stressed by the technicians involved in research on the subject.

The Municipality of Shanghai (10.8 million inhabitants, 50 percent of which are city dwellers) suffers from a scarcity of fish, in spite of the strides made in marine fisheries (240 fishing vessels), which produce 90 percent of the tonnage marketed today (200 000 t/year). The municipality wishes to develop urban industrial fish culture. Three types of systems of intensive culture are under review: an open system and a system involving partial or complete recycling of the water. To reduce the length of the production cycle, experiments have been carried out for the past two years using hot water wastes (25-28°C) from hydro-electric plants and annual outputs totalling 300 t/ha have been obtained. It is planned to use this in the near future on a pilot scale in 1.33 ha of cement pond.

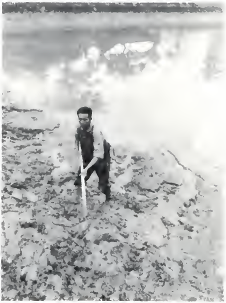


Figure 48 Cleaning a pond and removing a layer of silt (Photo F. Botts)

It is also planned to practise intensive farming in 67 ha of pond. With this is mind, complete, balanced fish feed have been developed from by-products which are available in larger quantities in the region of Shanghai: rice and barley bran, soy bean cake and fish meal. Dry granules containing 22-42 percent protein have been developed for intensive rearing of grass carps (floating granules)[1] and black carps (non-floating granules) with nutritional quotients in the region of 2.5-3. Stocking density is 2.5-3 specimens/m² (equal to 4 500 kg/ha). Artificial aeration at day-break becomes necessary as soon as the ichthyomass reaches 7 500 kg/ha. Average output varies between 15 and 22.5 t/ha/year.

Research is also underway at the Institute of Aquatic Products at Zhu Jiang, Guangzhou (Section 4.1.1). They are experimenting with intensive grass carp rearing in cement ponds of 4 m³ capacity with partial recycling of water. Specimens of an average weight of 250 g are stocked at a density of 80-100 specimens/m³, i.e., 20-25 kg/m³. Water in the ponds is changed four to six times every 24 h. Dry granules are distributed at the daily rate of 2-4 percent of the biomass present. The protein content of these granules varies from 30 to 50 percent (young fish) to 20 percent (older fish) and their nutritional quotient is approximately 2.6. Green fodder is distributed (Qu 10-15) as supplementary feed. Grass carps grow by 750 g in 30 days and reach the final weight of 1 kg. Average output is therefore 40-50 kg/m³/month.

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[1] The study group watched floating granules being prepared for grass carps when they visited the 'Liberation' People's Commune (Qingpu district, Shanghai). They contained: wheat bran (30% dry weight); barley bran (25%); soy bean cake (15%); fish meal (15%); green fodder (10%) and maize (5%); final water content: 22%;cost price: Y 0.5/kg

7.2 Intensive Fish Culture on a Pilot Scale

The study group was able to observe the intensive farming system applied to a pilot production of either grass carps (Qingshan Reservoir) or Japanese eels (Hangzon).

Downstream from the Qingshan Dam, the Municipality of Hangzhou has set up a centre for intensive fish culture, which utilizes the water which feeds the turbines of the hydro-electric plant (Figures 37 and 49). Intensive production of grass carps weighing 1 kg, is practised every year during the hot season (May-October) when the temperature of the water is around 22-25°C. Sixteen cement ponds, each of a capacity of 24 m^3 are stocked with 18 cm (40 g) fingerlings at a density of 125 specimens/m^3, i.e., 5 kg/m^3. These fish are fed several times a day with floating granules containing 20 percent proteins (cost Y 0.15/kg) at a daily rate of 3-4 percent of the biomass. Their nutritional quotient is relatively low. Green fodder is distributed as a feed supplement (Qu 10-15). In five months of intensive rearing, each pond produces approximately 2 700 kg of grass carps, which is equal to an average net output of 100-110 kg/m^3, or an average 20-22 kg/m^3/month.

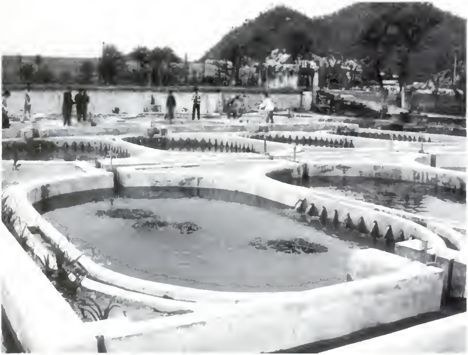

Figure 49 Intensive farming of grass carps at the Fish Culture Centre of the Qingshan Reservoir, Zhejiang

The Hangzhou Aquatic Products Experimental Centre also utilizes wastes from a hydroelectric power station for intensive fish culture. Eels (*Anguilla japonica*) have been reared in warm water (24-27°C) since February 1980, the aim being to produce specimens weighing 150-200 g (30-40 cm) in six months for export to Japan. The total surface area used is 2 733 m^2, 633 m^2 of which is under glass (Figure 50) and the rest in the open air, as follows: 3 cement ponds 51 m^2 each and 4 cement ponds, 120 m^2 each (under glass); 4 round ponds of 260 m^2 and 2 round ponds of 530 m^2 (outdoor). Elvers (0.12-0.14 g) from the briny waters of the province, are stocked in the smallest basins at a rate of 0.5 kg/m^3. When this rate reaches 2 kg/m^3 after about 20 days rearing, the young eels are sorted by size and transferred to ponds of twice the capacity. The initial stocking rate is again 0.5 kg/m^3. When the biomass reaches 2 kg/m^3, the eels are once again sorted and transferred to larger ponds. The same procedure is repeated a third time, until the final harvest is carried out in the largest ponds. Feed, based on fishmeal to which vitamins are added (cost Y 2/kg) is distributed, shielded from the light, in the form of a paste, at a daily ration of 6-8 percent of the biomass. A nutritional quotient close to 2 is expected. Water recirculation is important. A dissolved oxygen content of at least 60 percent of the saturation rate is maintained by means of a supply of compressed air and, if necessary, by means of floating paddle aerators. During the annual rearing cycle a gross output of 28 t of eel can be expected in six months, i.e., an average of 10.25 kg/m^2.

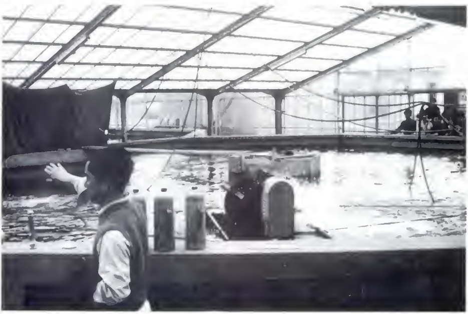

Figure 50 Intensive eel farming at the Hangzhou Experimental Centre, Zhejiang. View of one of the cement ponds under glass equipped with a floating aerator and a tent for artificial feeding

8. EXTENSIVE FISH CULTURE IN RIVERS AND CHANNELS

In certain provinces in China, mainly in the regions of the Chang Jiang (e.g., Jiangsu and Zhejiang) and Zhu Jiang (Guangdong) deltas, the small rivers and navigable channels can be prepared for extensive fish farming. Outlay is relatively small, usually consisting of the erection of barriers to prevent the escape of fish stocked.

The study group was able to observe this type of fish culture activity on two occassions: development of a small river in the Xinhui district (Guangdong) for fish culture activities and extensive farming in channels at the Annex of the Shaoxing District Fish Culture Centre (Zhejiang).

8.1 Extensive Fish Culture in Small Rivers

The Tangxia (Xinhui, Guangdong) People's Commune is concerned with farming a stretch of the main channel of the Tiansha River (20 km) and secondary channels flowing into it (30 km), i.e., 50 km of channel along a total length of 140 km. A part of this farm is operated by the people's commune itself (140 ha) and the rest by five production brigades (approximately 233 ha). The comments below refer to the communal farm.

The boundaries of the farming zone are demarcated by fences made of netting of different mesh sizes. There are five relatively large fences - two in the main channel and three at the mouths of the tributaries. The largest is 136 m long and a maximum of 7 m deep (Figure 51). Thirty-one smaller fences, about 3-4 m long and less than 4 m deep are placed at the mouths of other tributaries. Since navigation has to be allowed in a main channel, a passage fitted with a moveable fence is provided in each of the two fences which have been set up there.

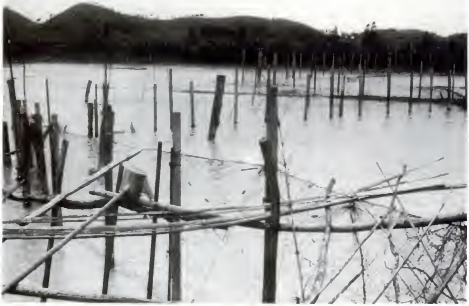

Figure 51 Extensive fish culture in the Tiansha River. Tangxia People's Commune, Guangdong. View of the main fence (136 m) installed in a zigzag across the river

So as not to hinder the flow of the river and in order to reduce the force exerted on the sections of netting which made up these large barriers, they are deployed in a zigzag fashion, the straight line of which is perpendicular to the line of the channel, and their total length is thus increased.

The channels were stocked for the first time in 1974 and annual stocking has been carried out since (Table 33). Large fingerlings (150–250 g) of the four carp species are now stocked once a year, at the rate of 714 fish/ha, to allow extensive polyculture based on bighead (50 percent) and silver carps (40 percent). During the first four years, average harvests were 180 kg/ha/year. In 1979, however, yield increased slightly to 195 kg/ha/year. This earned Y 30 000, a third of which represented the farm's profits. Annual yield from extensive farming in rivers can generally vary between 135 and 645 kg/ha, depending on the sector considered. The results mentioned above are not therefore among the best.

Table 33

Stocking carried out by the Tangxia People's Commune
for extensive fish culture in 140 ha of river

Species	1974			1976–79		
	Total No. of fish	Density N/ha	%	Total No. of fish	Density N/ha	%
Bighead carp	60 000	428	40	50 000	357	50
Silver carp	50 000	357	33	40 000	286	40
Grass carp	30 000	215	20	10 000	71	10
Common carp	10 000	71	7			
Total	150 000	1 071	100	100 000	714	100

In most cases, fish culture management is restricted to:

(i) ensuring navigation by opening and closing the moveable section of the main fences;
(ii) cleaning the fences, especially after heavy rains;
(iii) repairing the fences and the nets in particular;
(iv) controlling the predatory fish by selective fishing;
(v) stocking, and
(vi) harvesting.

Fertilizing and feeding is rarely done and then only semi-intensively. Some natural fertilizing may however occur from run-off water from cultivated areas.

It would appear that on some occasions, fry for stocking are reared in artificially made pools in the farming areas (ADCP, 1979). These pools are stocked with very young fish (3–4 days old), as soon as they become cut off from the river in the dry season. Semi-intensive fry rearing is therefore carried out until the waters rise again and become automatically stocked. The fry are then sufficiently large (200–300 g) that later mortality is limited to between 20 and 40 percent.

8.2 Extensive Fish Culture in Channels

In the district of Shaoxing (Zhejiang), there is an ancient tradition of extensive fish culture in the many navigable channels[1] which criss-cross the region. Currently, 12 693 ha are being farmed, either by the State, represented by the district (6 360 ha) and the District's Fish Culture Centre (1 200 ha), or by the people's communes (5 133 ha). The average depth of the water is 3 m.

In order to facilitate management operations, the channels are divided into sections of 40-53 ha, by means of blocking devices made of bamboo and netting. Boats are allowed to pass through a moveable gate which opens and closes automatically or is manually operated (Figures 52 and 53). Management of these sections includes:

(i) maintenance of the barriers;
(ii) annual stocking;
(iii) control of predatory fish by means of intensive fishing;
(iv) regulating the minimum size of fish fished (over 0.5 kg), as well as the fishing grounds and seasons, and
(v) harvesting the food fish in winter, using a seine net.

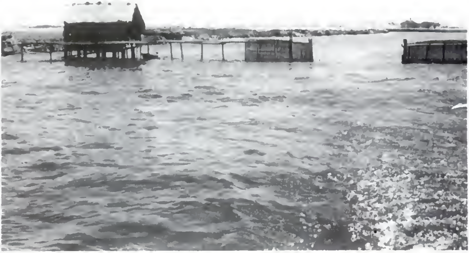

Figure 52 Extensive fish culture in navigable channels; barrier separating two sections of the channel, with moveable, manually operated gate and operator's house. District of Shaoxing, Zhejiang

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[1] The Chinese translators use the term 'small lakes', but they are branches of rivers or 'channels' used for boat transport, irrigation and drainage

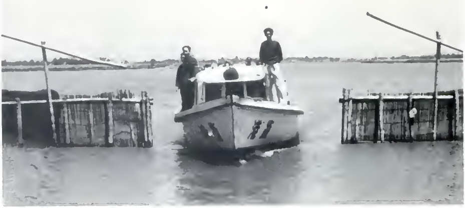

Figure 53 Barrier separating two sections of the channel, with automatic moveable gate. District of Shaoxing, Zhejiang

Stocking is done twice a year, in spring and summer. Depending on the section of the channel involved, 1 800 fish/ha (fry weighing 15 g or 10-15 cm long), or 960 fish/ha (fingerlings weighing 250 g) are stocked. Extensive polyculture of bighead (60 percent) and silver carps (40 percent) is practised. When aquatic plants are available, a limited number of grass carps and Wuchang bream are added. Most of the fry are produced locally in floating cages (Section 5.4). It must be pointed out that the first stocking of a section takes place only after exhaustive fishing of the predatory fish which live there naturally. Thereafter, the relative numbers of these fish are minimal and this level is easily maintained by regular selective fishing.

An average of 300-1 350 kg/ha of marketable fish is harvested annually. The best yields are obtained when the following rules of fish culture management are applied:

(i) stocking of young fry weighing 20-50 g;
(ii) increasing stocking density;
(iii) polyculture of a larger number of complementary fish species; up to 10 species;
(iv) the practice of rotational fishing - summer harvesting of fingerling and winter harvesting of food-fish, and
(v) intensifying the fishing rate which has gradually increased from 20 percent to over 90 percent.

This type of management is conducted by the Annex to the Fish Culture Centre of the district of Shaoxing which farms 335 ha of channels. Average annual output up to 1978, was 900 kg/ha. However, improved management practices resulted in an output of 1 125 kg/ha in 1979, i.e., an average increase of 5 600 kg of fish per salaried employee.

9. EXTENSIVE FISH CULTURE IN NATURAL LAKES

9.1 Fish Culture Development and Management in Natural Lakes

In China, lakes are classified into three categories according to their surface area (ADCP, 1979):

(a) large lake: body of water exceeding 6 667 ha in area (more than 100 000 mu);
(b) medium lake: from 667 to 6 667 ha (10 000 to 100 000 mu), and
(c) small lake: from 67 to 667 ha (1 000 to 10 000 mu).

Bodies of water of less than 1 000 mu in area are considered (for statistical purposes) as ponds.

The larger the surface area of a lake, the more extensive is its development and management. With a view to increasing fish production through fish culture management, more attention is focused on small lakes. This type of fish culture is particularly well-developed in the provinces of Chang Jiang Valley (e.g., Hubei, Anhui, Jiangsu and Zhejiang), where the best yields are obtained. The farming system however remains extensive, although in some cases, and only in lakes measuring some hundreds of hectares at most, organic fertilization (pig manure) and supplementary feeding (plants) are applied. The rates of application nevertheless remain much lower than those observed in fish ponds.

Development and management are collective activities which are carried out either at State level (State, district or municipality farm) or people's commune level (e.g., production brigade or people's commune itself). The aspect of the Chinese system which is particularly attractive, is that the same group is concerned with development and management. In the course of the year, the latter includes all fish culture activities, from initial stocking to final fishing. The results in an increasing sense of responsibility on the part of all members of the farming community who are directly concerned in the results of their own efforts.

Fish farming is not necessarily restricted to fish, but may also include other aquatic animals, such as crabs and shrimp at Tai Hu (Section 9.6). Fish farming moreover, usually includes other related aquatic activities, such as gathering and cultivation of aquatic plants (lotus, water hyacinth, rush, etc.), harvesting molluscs and removing organic silt. In addition, all these lake-based activities are closely linked with land farming activities which are carried out in the immediate vicinity of the lake, since it is easy to integrate all the different activities. At the Baitan Hu State Farm, for example, the study group was able to observe the following integrated activities: fish production in deep water, lotus production in shallow water, rice in marginal zones and mulberry/trees on the artificial dykes. Up to 20 percent of the total revenue from the lake is obtained from crops which are cultivated in combination with fish farming (Figure 54).

Development of natural lakes for fish culture generally includes the following activities:

(i) regulating the level of the body of water, by installing pumping stations and weirs;
(ii) constructing barriers and fences to prevent the fish from escaping from the lake via its tributaries, and
(iii) setting up spawning ponds (Figures 55 and 56) with a view to increasing the chances for successful spawning and in particular of species whose eggs become attached to the underwater vegetation (Tai Hu - Section 9.6).

Moreover, the current trend is to convert the shallower zones of natural lakes into large fish culture ponds, for more intensive fish culture. At Tai Hu, a dyke, built across a bay allowed 150 ha of lakeside land to be sub-divided into fish culture ponds.

The purpose of fish culture management is, if not to improve, at least to maintain fish culture production at an adequate level. During the course of the year, various operations are carried out, the principal ones being:

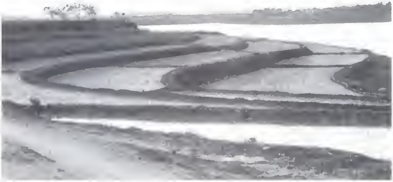

Figure 54 Agricultural development of the banks of the Baitan Hu, district of Huanggang, Hubei

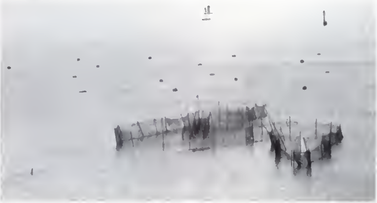

Figure 55 Developed zone of the Tai Hu and fixed fishing gear. Wuxi, Jiangsu

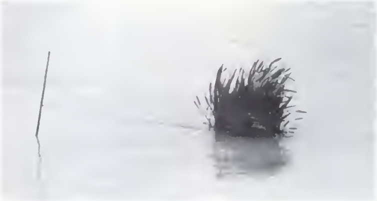

Figure 56 Details of a clump of floating grass attached to a bamboo pole, in the developed zone of the Tai Hu, Wuxi, Jiangsu

(i) Stocking

The natural fish fauna found in Chinese lakes is not very varied and cannot utilize all the available natural resources. Polyculture of Chinese carps, combined with other fish species, allows these resources to be put to better use and this solution is at the basis of Chinese fish culture in natural lakes. However, river fish species do not spawn naturally in a limnetic environment and periodic stocking is necessary to maintain the fish population at an adequate level to allow regular fishing of stocks. Stocking is done once a year, usually in the spring, with locally produced fry. The size and the number of fingerlings stocked varies according to local production potential (Table 34). The present trend is to use fairly large fingerlings as far as possible, in order to reduce later mortality, and to increase stocking density. While formerly, less than 1 000 fingerlings of between 6 and 7 cm were stocked per hectare, today, attempts are being made to stock an average of at least 1 500 (and even 2 250) 15-20 cm fingerlings (weighing over 50 g). Usually the species chosen include at least two of the Chinese family carps and preferably the bighead and silver plankton feeding carps, as well as Wuchang bream, the crucian carp and other species, according to the trophic conditions of the lake.

(ii) Predator control

This is done only in small and medium lakes, where it is used to reduce the ichthyophagic fish populations (*Siniperca chautsi*, *S. scherzeri* and *Elopichthys bambusa*) as far as possible. The methods used are based mainly on the acquired knowledge of the life cycle and behaviour of each of these species. For example, when the fish gather together at spawning time, large numbers can be captured with seine nets; the spawners themselves can be destroyed; holes may be dug in the lake bed where some predators go to take refuge and can thus be located and fished more easily.

(iii) Fishing regulations

They may apply to the fishing season (protection of fish during the spawning season), the fishing grounds (protection of spawners), fishing gear (protection of fish weighing less than 0.5 kg) and fishing methods (no poison or explosives). Poaching appears to be unknown in China, but if it were to be discovered, it is more than probable that it would be severely condemned by the whole community.

(iv) Controlling the water level and maintaining the barriers/fences

(v) Harvesting of fish

This is done by successive fishing with trawls, purse seines, beach seines, gillnets, fykenets, traps, etc. Special techniques have been developed locally to enable the fish to be grouped together in certain parts of the lake, to facilitate harvesting.

9.2 Fish Production in Natural Lakes

The national annual average fish yield in natural lakes totalled 135 kg/ha in 1978 (Table 8). This yield however varies from lake to lake and, in particular, depends on the surface area. Indeed, productivity declines as surface area increases. This is a ratio that is equally well established for natural lakes in other regions of the globe. On the basis of this, annual average productivity in Chinese lakes was estimated in the past, by Tapiador, *et al.* (1978), as varying from 1 000 kg/ha in small lakes, to 225 kg/ha in medium lakes and 60 kg/ha in large lakes. It is probable that since 1976, when these estimates were made, improved fish culture management has resulted in an increase in average figures.

It would not appear however that total lake output has increased in a similar way, following the thrust given to more intensive farming methods (agriculture or fish) in shallow lake areas. Official statistics show that the total surface area used for fish cultivation in lakes recently declined from 531 100 ha (1978) to 484 793 ha (1979), i.e., a reduction of 46 307 ha in one year (Zhu De-Shan, 1980; Song, pers. comm., 1980). It is useful to point out that during the same period, pond fish culture was extended over an additional 32 173 ha and fish culture in reservoirs (Chapter 10), over a further 45 613 ha.

Table 34

Extensive fish culture in some natural lakes

Lake (province)	Surface area (ha)	Average depth (m)	Main fish species	Stocking			Harvest	
				Size (cm)	Number (million)	Density (fish/ha)	t/year[b]	kg/ha
A. Small lakes								
Baitan Hu (Hubei)	400	2.5	Silver carp Bighead carp	16–20	0.9	2 250	300	750
Xi Hu (Zhejiang)	559	1.5	Silver carp Bighead carp	13	0.7	1 252	300 max. 550	536 max. 984
B. Medium lakes								
Tang/Est[a] (Hubei)	1 467	4–5	-	-	-	-	660*	450
Dianshan Hu (Shanghai)	6 670	max. 3	-	4–15	10	1 499	500	75
C. Large lakes								
Tai Hu (Jiangsu)	226 700 (213 330)	2	Bighead carp Silver carp Grass carp Black carp	10	10	47	11 980	56

[a] Ref. ADCP, 1979

[b] Figures for 1979, except * 1977

The harvests and yields obtained in some natural lakes are given in Table 34. Four of these lakes were visited by the writer during the study tour. So as to better illustrate the development and management procedures mentioned above, the more detailed information obtained on these visits is summarized above (Section 9.1). The lakes involved are, in order of magnitude: Baitan Hu, Hubei (400 ha); Xi Hu, Zhejiang (559 ha); Dianshan Hu, (6 670 ha) and Tai Hu, Jiangsu (226 700 ha). All are shallow; average depth does not exceed 5 m.

9.3 Baitan Hu

Development and management of Baitan Hu (district of Huanggang, Hubei) are among the activities of a State-owned farm, which specializes in fisheries and fish culture (Section 3.2). In 1979, its fry-rearing centre produced 50 million fry of 3 cm in length, 3 million of which were used by the farm itself, mostly to produce large fingerlings for stocking (16-20 cm) the lake. This Centre's output is relatively high and has been stable over the last seven years at 750 kg/ha/year. Prior to that, it was 450 kg/ha/year, when small fry of 6 cm were stocked at a density of approximately 1 500 specimens/ha only. Extensive polyculture includes 15 percent grass carps and a few Wuchang breams. The Centre is managed by 19 workers, under the supervision of technicians and senior staff. The current target is to increase output to 500 t/year.

9.4 Xi Hu

Over the ages, the Xi Hu Lake, in the west (Hangzhon, Zhejiang) had become very shallow (0.55 m), swampy and covered with grass. In 1956, its annual output did not reach 20 t, i.e., approximately 35 kg/ha. That same year, restoration was undertaken and its average depth increased to 1.80 m by the removal of 7 million cubic metres of earth. A fishermen's cooperative was also set up. In 1959, a fish culture centre was set up to take charge of developing and managing fish culture activities in the lake and reforesting the watershed. A third activity, tourism,has since been developed in the region. This prompted the authorities concerned to look into the possible interactions of this activity with measures of conservation for the lake and its immediate surroundings.

The main features of the Xi Hu Lake can be summarized as follows:

(a) Morphometry: watershed 2 122 ha; lake 603 ha, 559 ha of which is under water; shape, oval (2.8 x 3.3 km), circumference 15 km; bottom, flat; average depth (1979), 1.50 m maintained constant by means of a drainage weir at the northeast side;

(b) Quality of water: temperature 20°C from April to October; dissolved oxygen 8-13 mg/litre; pH 8.4-9.6; dissolved salts 130 mg/litre; visibility depth 25-45 cm; eutrophic, and

(c) Plankton: large quantities, most of it phytoplankton (average 43 mg/litre), more than 94 percent of which is made up of *Microcystis*.

Extensive polyculture is based on annual stocking of 13-cm long fingerlings of the silver carp (60 percent) and bighead carp (25 percent) species. Other species (common carp, Wuchang bream, crucian carp) are stocked at 7 cm. More than 50 different species are present in the lake. More than 110 persons are employed for management activities. Marketable size is fairly small (0.5-1 kg). Average annual production is 300 t, i.e., 536 kg/ha. In the past, however, it reached 550 t, i.e., 984 kg/ha.

9.5 Dianshan Hu

The Dianshan Hu (district of Qingpu, Shanghai) is managed by the 'Liberation' People's Commune (Table 15). It is fed by 71 tributaries and its waters are poor in quality. In 10 years (1968-78), 10 of the natural species were lost because pollution of two main tributaries prevented migration. Decline in production to 320 t/year in 1977 was also due to other causes, such as closure of the communication system with the Chang Jiang, development of navigation and loss of aquatic plants. A research programme is underway (Shanghai Institute of Aquatic Products, Section 4.1.2). Since 1977, gradual improvements in fish culture management has already resulted in a rise in annual production, which reached 500 t (75 kg/ha) in 1979, i.e., a 56-percent increase in the last two years. Moreover, the mollusc harvest totals an average of several hundred kilogrammes per hectare (1976 = 450 kg/ha, according to Tapiador, *et al.*, 1977).

9.6 Tai Hu

China's third largest lake, the Tai Hu (Wuxi, Jiangsu), has a surface area of approximately 2 267 km², 2 133 km² of which is under water. This eutrophic lake, which is fed by the waters of the Chang Jiang and by several tributaries which originate in the surrounding mountains, has the following hydrobiological characteristics:

- circumference: 393 km
- depth: average 2 m and maximum 5 m
- type of bottoms: sludgy (50 percent) or hard
- average water temperature: 2°C in February and 29°C in July
- average dissolved oxygen 6 mg/litre, pH 7.5-8.5
- visibility depth: generally 1 m

The Tai Hu is managed at provincial level by a Management Committee. This Committee meets periodically with the representatives of the groups concerned (people's communes, production brigades, universities, districts, etc.) to examine the most recently obtained information concerning the lake. Since several activities are carried out (fisheries, aquatic plants, molluscs, crop irrigation), management tends to promote each one and at the same time encourage integration. A major decision of the Management Committee concerns measures to ensure fishery development and the protection of the fishery environment.

Fishery development and management includes:

(i) Stocking: once a year, in spring, fingerlings of the four family carp species (size 10 cm) in combination with other species (3 cm), such as common carp, Wuchang bream and the crucian carp; these 10 million fingerlings are produced locally in several fish culture centres. In 1978, 9 t of small crabs, fished in the Chang Jiang estuary, were also introduced;
(ii) Establishing and improving spawning ponds: planting underwater aquatic plants; introducing clumps of floating grass, anchored in particular areas (Figures 55 and 56);
(iii) Regulating the fishing season (two periods closed, separated by 20 days open) and fishing grounds (20 spawning areas closed in autumn);
(iv) Regulating water level: by weirs, and
(v) Fishing: 3 000 fishing boats and 20 000 fishermen active six months a year; using bottom trawls, gillnets, traps/fykenets.

Aquatic products harvested in 1979 totalled 113 500 t, broken down as follows:

(a) Aquatic plants (particularly surface plants) and molluscs: 100 000 t;
(b) Fish - small cyprinids (maximum 20 cm): 8 000 t
  - from annual stocking: 1 500 t
  - miscellaneous: 2 480 t
  Total 11 980 t;
(c) Shrimp (*Penaeus japonicus* and white shrimp): 770 t, and
(d) Crabs: 750 t.

Average annual fish yield is relatively low, approximately 56 kg/ha, 66.8 percent of which is made up of small cyprinids (*Coila ectenes*), which have little market value. Stocked species account for only 12.5 percent of the fishery. The natural fauna (101 species) is so unbalanced in favour of this small cyprinid, that the only hope of increasing fish production lies in heavier stocking of Chinese carps. Between 1953 and 1979, stocking and improved management, combined, resulted in a rise in production of fish culture species from 5 500 t (1953) to 13 500 t (1979). Shrimp (especially Japanese shrimp, which does not spawn naturally in lakes) and crabs also made this output possible and careful management of their stocks is also extremely important.

10. EXTENSIVE FISH CULTURE IN RESERVOIRS

China is said to possess approximately 2 million hectares of artificial lakes - or reservoirs - two-thirds of which are said to be used for extensive fish culture. Efforts have recently been made to extend the areas being exploited. In 1978 therefore, 1 208 427 ha of reservoirs were being managed (Zhu De-Shan, 1980), while in 1975 the figure was 1 254 040 ha, i.e., an increase of 3.77 percent (45 613 ha) in one year (Song, pers. comm., 1980). As extensive farming of these water areas developed, fish culture in cages became more widespread (Section 11.1).

Chinese reservoirs are classified either according to their capacity (for irrigation), or according to their surface area and are divided into three categories similar to those used for natural lakes (Section 9.1)[1]. Development and management are also group activities and are done either by the State (e.g., district or municipality), or by one or several people's communes. The same groups deal with both development and management.

Every reservoir is designed for multiple and integrated uses. The purpose of the Qingshan Reservoir (developed and managed by the Municipality of Hangzhou, Zhejiang) was mainly to regulate the flow of the river and at the same time, to produce hydro-electric energy (Table 35). In addition, however, the valley downstream (Figure 57) was developed so that the turbine reject water could be used for the irrigation of agricultural crops and for feeding an intensive fish culture centre (Section 7.2). The reservoir is used for the transport of products, production of stocking fry in cages (Section 5.4) and pens (Section 5.5) and for the production of food-fish.

Development of the reservoirs for fish culture purposes generally consists of:

(a) Installing a protection net upstream from the turbine water inlet pipe (Figure 58);
(b) Constructing barriers to prevent the fish from escaping into the tributaries, and
(c) In small reservoirs only, preparing the bottom before flooding (either partial or over the whole area), in order to facilitate later fishing operations: removal of trees, removal of obstacles, such as tree stumps and large rocks, levelling.

Fish culture management in reservoirs is also fairly restricted. Stocking and fishing are the two principal activities. The two major problems at the moment consist of controlling ichthyophagic fish and fishing technology. At the Qingshan Reservoir, fishing is done in spring, using gillnets (harvesting common and crucian carps) and in winter, using a fykenet at a depth of up to 13 m (bighead and silver carps). At the Bailianhe Reservoir, on the other hand, fishing is done once a year, in autumn and only fykenets are used. When stocking is not carried out, little fishing is done. On the other hand, floating cage rearing is practised on a large scale (Section 11.1).

Chinese technicians consider that fish yields in reservoirs are generally lower by about a third than those in natural lakes of the same size. In 1978, the national average yield was 90 kg/ha (Table 8). Yield however varies from reservoir to reservoir. In the absence of planning and management, the very large Bailianhe Reservoir (41 300 ha) produces only 12 kg/ha/year, while the large Miyun Reservoir (9 300 ha), which is stocked once a year produces 150 kg/ha/year (Table 35). The Qingshan Reservoir (1 800 ha), which is well managed, gives a maximum annual yield of 870 kg/ha. Chinese reservoirs are therefore thought to have a high production potential and to achieve it fully, surveys must be carried out on a large scale.

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[1] A reservoir classification better suited to fish culture was recently proposed by Song (1980): more than 1 000 ha (large; 100-1 000 ha (medium); less than 100 ha (small))

Table 35

Extensive fish culture in some reservoirs

Reservoir (province)	Features of the reservoir		Extensive fish culture			Other uses of the reservoir
	Dam	Body of water	Stocking	Harvest t/year	Harvest t/year	
Qingshan (Zhejiang)	- earth/rock - L of top 575 m - H of top 24 m	- max. depth 21 m - av. depth 12 m - max. surface area 1 800 ha - av. surface area 530 ha	- annual - 200–250 g - 300 000 specimens (566/ha)	av. 345 (1979) max. 461	av. 650 max. 870	- Fry production in cages and encloaures - Intensive fish culture in ponds (downstream) - Production of hydro-electric energy - Irrigation: orchard and grains (downstream) - Transport: (coal mines)
Bailianhe (Hubei)	- earth/rock - L of top 259 m - H of top 69 m	- max. depth 49 m - av. depth 20 m - av. surface area 413 km²	nil	500 (1979)	12+	- Extensive fish culture in cages (7.2 ha) - Production of hydro-electric energy - Irrigation (35 333 ha)
Meichuan[a] (Hubei)	-	- depth 7.5–19.5 m - av. surface area 2 500 ha	annual 9–12 cm	100 (1977)	40	
Miyun[b] (Beijing)	-	- av. surface area 9 300 ha	annual	(1976)	150	
Holung[b] (Guangdong)	-	- av. depth 8.3 m - av. surface area 200 ha	annual	(1976)	70	

[a] Reference ADCP, 1979; with green fodder and pig manure totalling 600 t/year

[b] Reference Tapiador, *et al.*, 1977

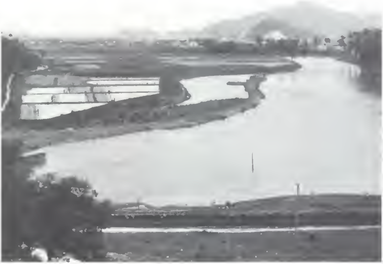

Figure 57 Integrated development of the lower valley of the Qingshan Reservoir (Zhejiang): re-utilization of turbine reject water for crop irrigation and pond fish culture. In the foreground, a feed canal crossing the valley

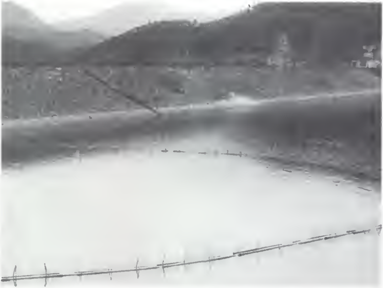

Figure 58 Protection net upstream from the turbine water inlet pipe at the Qingshan Reservoir, Zhejiang

The study group was able to visit two reservoirs during their tour (Table 35). The Qingshan Reservoir (Zhejiang) was built in 1960. Its maximum capacity is 200 million cubic metres. Before flooding, only the largest trees were removed. It is well managed by the Hangzhou Municipality and gives an excellent fish yield. The water level varies between +31.7 m (July-September) and +16 m (November-January), i.e., a maximum annual range of about 15.7 m. The Bailianhe Reservoir (Hubei, Figure 59), built in 1959 on the Xi Shui, is a large body of water of 413 km², the level of which may fluctuate by 18.5 m annually. This river is exploited jointly by three districts, including the Xishui and Yingshan districts. The Huanggang Prefecture is in charge of management, which however does not cover extensive fish culture. Fishing is not very developed and efforts are concentrated on cage production of fish (Section 11.1).

Figure 59 Study group briefing prior to visit of the Bailianhe Reservoir, district of Xishui, Hubei

11. FOOD-FISH PRODUCTION IN CAGES

Fish rearing in cages is a relatively recent activity in China, which is becoming more widespread. This farming system is carried out in different environments, either still on an experimental scale, or already on an industrial scale. Since fingerling production using this system has already been dealt with (Section 5.4), this section will deal with cage production of food-fish. The main data collected during the study tour are given in Table 36.

11.1 Extensive Fish Culture on an Industrial Scale in Reservoirs

The district of Xishui (Hubei) has been developing fish culture in floating cages in the Bailianhe Reservoir since 1976. In May 1980, more than 7 ha of cages (approximately 2 400 units) were being farmed by 300 persons, 5.1 ha for food-fish production. A future expansion of this type of farming over a further 5 000 m² was already being planned.

The cages consist of a floating bamboo frame to which is attached a net bag made of polyethylene (Figures 60 and 61). Unit capacity is 56 or 64 m³. The mesh is relatively small (maximum 2.5 cm). The frame usually lasts 2 years and the net 3-4 years.

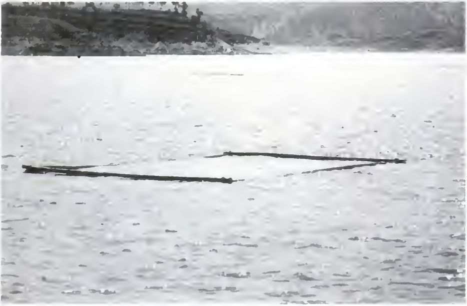

Figure 60 Extensive fish culture in floating cages, Bailianhe, Hubei

Table 36

Cage production of food-fish

Location	Bailianhe Reservoir (Xishui, Hubei)	Dianshan Hu (Qingpu, Shanghai)	Qiantang Jiang Tributary (Hangzhou, Zhejiang)
1. Rearing cages	floating	fixed	floating
- unit area	28-32 m^2 x 2 = 56-64 m^3	30-85 m^2 x 2 = 60-170 m^3	approx. 30 m^2 x 2 m
- mesh, cm	1.5-2.5	1.25	
- density, cages/ha of water	approx. 8(240 m^2/ha)	approx. 46(1 360 m^2/ha)	
2. Stocking			
- size/unit weight	13 cm/25 g	200-250 g	50+ g
- density, specimens/m^2	25	9-18	20
- rate, kg/m^3	0.30-0.35	1-2.25	0.50
- polyculture (%)	silver carp 85 bighead carp 10 grass + black carps 4 Wuchang bream 1	grass carp 94 bighead carp 2 crucian carp 2 *X. argentea* 2	grass feeders 70 plankton feeders 30
3. Diet	natural	floating granules	granules + fodder
4. Duration of rearing	12-18 months (growth 6 months/year)	6 months	10 months
5. Yield			
- size/unit weight	0.5+ kg	1-1.5 kg	0.1-1.5 kg
- rate, kg/m^3	5.6-7.5	9 (max. 13.5)	7.5 (max. 11.3)
6. Production			
- total kg/m^3	5.3-7.5/year	8 (max. 11.3)	7 (max. 10.8)
- monthly average, kg/m^3	0.44-0.63	1.33 (1.90)	0.70 (max. 1.10)
- annual, t/ha	2.5-3.6	41-58	

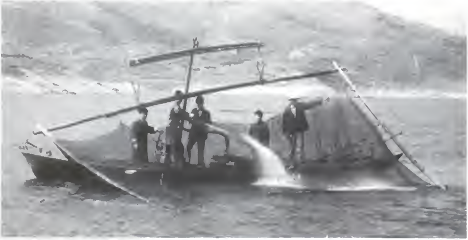

Figure 61 Bailianhe Reservoir, Hubei: on-the-spot cleaning of a floating cage net using a pressurized jet of water

The farming site is usually chosen to allow 2 m of water under the cages in all seasons. Since this type of farming is based essentially on natural feeding, the floating cages are anchored in areas of the reservoir which are rich in plankton, at a distance of 30 m from each other. They occupy an average of 240 m^2/ha of the water area, at a rate of 8 cages/ha.

Polyculture is practised with the silver carp as the principal species (85 percent), in combination with grass and black carps (4 percent) and Wuchang bream (1 percent), to control the organisms growing on the net. To start with an average number of 25 fingerlings weighing around 25 g (13 cm) are stocked/m^2 of cage. Since the annual growing period is only six months (May to October), it takes 12-18 months to produce food-fish weighing at least 0.5 kg.

During rearing, no supplementary feed is provided. Annual average production is relatively low - 11.2-15 kg/m^2. This type of extensive fish culture is nevertheless considered advantageous in view of the small outlay involved (cost of net: Y 80) and the low cost of production. The food-fish costs Y 0.5/kg to produce and is sold to the State at Y 0.78/kg, which is considered a very satisfactory profit. Based on current costs, it is estimated that maximum profit would be obtainable with a farming area of 2 000 m^2/person.

The only operation which must be done periodically is the cleaning of the nets. This is done on the spot, using a motor operated pump and jet of pressurized water (Figure 61). In summer this operation must be repeated every 6-10 days, while in winter, at 1-2 month intervals.

11.2 Experimental Intensive Fish Culture in Natural Lakes

The district of Qingpu (Shanghai) has been conducting experiments on cage farming in the Dianshan Hu since 1979 (Section 9.5). The 'Liberation' People's Commune is in charge of these farms (Table 15).

A shallow area (maximum 3 m) of the lake was cut off by a protective bamboo screen. Fixed cages are arranged in this area in rows 12 m apart (Figure 62). In each row the cages are 4 m apart. A staggered row arrangement is also being experimented. The total surface area of the cages is 2 490 m² for 65 units. They cover an average of 1 360 m²/ha of water at a rate of approximately 46 cages/ha.

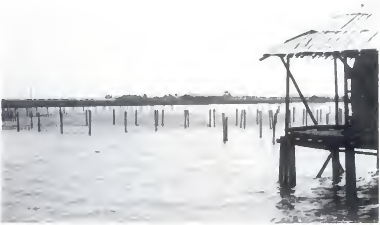

Figure 62 Experimental fish farming in cages in the Dianshan Hu, district of Qingpu, Shanghai. Protected enclosure and watchman's house

The fixed cages consist of a nylon net bag, attached to a number of bamboo poles (Figure 63). The depth of water in the cages never exceeds 2 m and the net is therefore 0.5-1 m from the bottom. Three sizes of cage are being tested: 30.5 - 36 - 85 m².

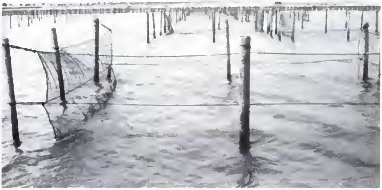

Figure 63 Dianshan Hu, Shanghai: fixed cages for intensive fish polyculture

Polyculture is practised where the grass carp is the principal species (94%), which is combined with bighead carps (2%), crucian carps (2%) and *Xenocypris argentea* (2%). These last two brousing species are used to control net fouling.

Large fingerlings (200-250 g) are stocked in April at three different densities (9 - 12 - 18 specimens/m²). The fish are fed floating granules (daily ration 2% biomass) and aquatic grasses. The granules are made of soy bean cake (50%), colza cake (30%), barley or wheat bran(15%) and fish meal (5%). They are manufactured locally at a price of Y 0.44/kg and their nutritional quotient in the cages is relatively low (Qu 2). Harvesting takes place after about six months of rearing and fish weighing 1-1.5 kg are taken. The only disease observed has been enteritis in grass carps.

Net cage output in 1979 was 16.1 kg/m² on average. Grass carps are therefore produced at a cost of Y 1.50/kg and are sold for Y 1.60/kg, which is a very small profit margin. The cost price includes the cost of fry, the cost of the cage, which is amortized in three years (e.g., a cage measuring 36 m² x 2 m = 72 m³ costs Y 180), the cost of artificial feed and labour. As regards the latter, it is estimated that an average of five persons per mu of cages (667 m²) are required for stocking, making granules, daily feeding, cage maintenance, supervision, harvesting, etc.

11.3 Experimental Intensive Fish Culture in Rivers

The Hengzhou Experimental Centre of Aquatic Products (Zhejiang) is carrying out experiments on intensive fish culture in floating cages, in a tributary of the Qiantang Jiang (Figure 64). The depth of water varies between 3 and 4 m, depending on the season.

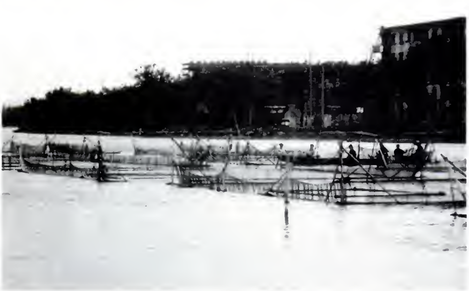

Figure 64 Fish farming in cages in the Qiantang River, at the Hangzhou Experimental Centre, Zhejiang

The farm covers a total area of 2 000 m² of cages of a depth of 2 m, i.e., a total capacity of 4 000 m³. Carp polyculture (grass, silver, bighead, common carps) is practised in combination with Wuchang bream and *Sarotherodon mossambicus*. The fish are fed on fodder and rice bran or wheat bran granules.

Fingerlings weighing 50 g are stocked at a density of 20 specimens/m². After ten months rearing, food-fish of variable individual weights are harvested: tilapia 100-250 g; Wuchang bream 500 g; grass carp 1-1.5 kg; other carps 0.5-1 kg. The average harvest is 15 kg/m², although a maximum of 22.5 kg/m² was obtained in the past.

It must be mentioned here that fingerlings (Section 5.4) have already been produced in navigable channels in Zhejiang province. Similar technology could be applied to food-fish production (Figure 65).

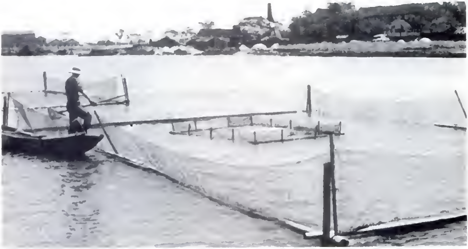

Figure 65 Fixed cages in the channels in the district of Shaoxing, Zhejiang. Artificial feed is distributed in the tray inside the main frame

12. CULTURED PEARL PRODUCTION IN FRESH WATER

In China, fresh-water mussel-rearing to produce cultured pearls can be done in natural lakes, reservoirs or ponds. The study group was able to observe this type of aquaculture (Figure 66) at the Fish Culture Centre of the Qingpu district.

Three species of pearl-producing mussels are reared there in ponds: *Hyriopsis cumingi* (the best), *Cristaria plicata* and *Anodonta woodiana*. Several dozen small pieces of mantle, taken from mussels killed for the purpose, are first implanted between the mantle and the shell of each pearl mussel. An average of four mantles per pearl mussel is used and a skilled worker can prepare about 30 mussels per day.

The mussels are then placed in ponds, suspended individually by a vertical thread. Stocking density is 150-225 mussels per 100 m² of water. Two summers later (water temperature 20-25°C), up to 40-50 cultured pearls per mussel are harvested, depending on the number of nuclei implanted.

The quality of the pearls produced in this way varies widely. Even though, in China they are used chiefly for medicinal purposes and their shape and quality are not as important as in Japan, the price can treble depending on whether they are classified in the fourth (Y 700/kg) or first (Y 2 000/kg) category.

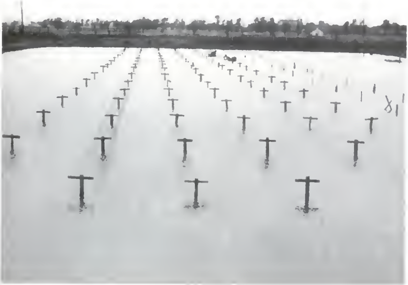

Figure 66 Pearl mussel farming in ponds. Qingpu District Fish Culture Centre, Shanghai

One hundred pearl mussels produce an average of 0.5 kg of cultured pearls, i.e., a yield of 0.75-1.125 kg/100 m² of pond. Income from this activity can be advantageous if the quality of the pearls is good, particularly when they are farmed in natural lakes or reservoirs where it is possible to intensify farming without much investment being necessary. This applies to the 'Liberation' People's Commune (district of Qingpu, Shanghai), which farms in this way in the Dianshan Hu and produces 500 kg of pearls/year.

13. MARKETING FRESHWATER FISH

13.1 Distribution and Marketing of Fry and Fingerling

13.1.1 Transport of fry and fingerling

As previously mentioned, fry of different ages and sizes (8 days, 3 cm, 13 cm, etc.), are produced either in the State-run fry-rearing stations (e.g., district and State farm), or in the centres run by the people's communes (Section 5). These stations generally produce fry not only for their own requirements but to sell to other groups of fish cultivators. This activity can in fact constitute a fairly large proportion of annual income from fish culture.

The technology used for the transport of fry and fingerlings depends mainly on the rate of dissolved oxygen consumption (RDOC) of the fish transported. A few typical examples are given in Table 37. A review of these figures suggests that:

(a) RDOC falls considerably as we move from the larval stage to the small fry stage. Thereafter, it continues to fall, but not as quickly;
(b) RDOC falls when the temperatures of the water drop, and
(c) RDOC varies from species to species.

Table 37

Dissolved oxygen consumption rate of Chinese carp fry
(adapted from Anon., 1980, page 68)

Species	Water temperature (°C)	Unit weight (g)	Dissolved oxygen consumption (mg/g/h)
Bighead carp	27.8	0.00251	5.130
	28.9	0.815	0.893
	30.0	1.02	0.912
Silver carp	26.0	0.00245	5.000
	18.0	9.00	0.280
	21.5	9.66	0.318
	24.2	13.50	0.224
	29.0	15.00	0.293
Grass carp	27.5	0.0027	4.140
	32.0	0.0027	4.350
	30.0	0.36	1.000
	22.0	9.33	0.296
Mud carp	26.0	8.50	0.230
	26.0	10.00	0.190

This shows that three major rules regarding fry transport must be followed. The weight of fry and fingerlings/litre of water:

(i) Is minimal for larvae and gradually increases as the weight of the individual fry increases;
(ii) Is higher in the cold season than in the hot season, and
(iii) Is all the higher when the fry and fingerlings involved are bighead, silver, grass and mud carps.

Attention must also be paid to the duration of transport.

Several methods of transport are currently used in China. For short distances, woven bamboo baskets or wooden buckets are preferred. They are suspended to each end of a bamboo pole, which is carried on the shoulder (Figure 67). For longer distances, various containers made of waterproof canvas or wood, boats with perforated sides, as well as plastic bags are used.

The use of the latter method is becoming increasingly widespread and it was demonstrated to the study group by the technicians at the Hengjiang Fry-Rearing Centre (district of Xinhui, Guangdong). It consists in filling a plastic bag (polyethylene, 0.5-0.1 mm thick) with clean, fresh water, to a third or a quarter of its capacity (Figure 68). A known quantity of fry are placed in it. The air in the bag is then expelled and replaced by oxygen under pressure. The bag, which is hermetically sealed, is then laid flat in a cardboard carton, specially designed for this purpose (Figure 69). The carton is tied up with string and is ready for transport by road, rail, or even air (Figure 70).

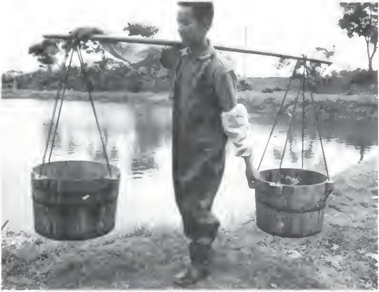

Figure 67 Transport of fry over short distances (Photo: F. Botts)

Figure 68 Preparation of plastic bags for transporting eight-day old fry, Xinhui Fry-Rearing Centre, Guangdong

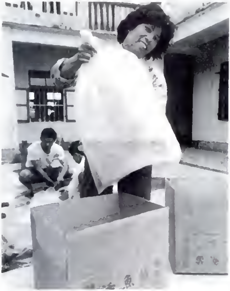

Figure 69 Plastic bags containing the fry are inflated with air and placed in cardboard cartons

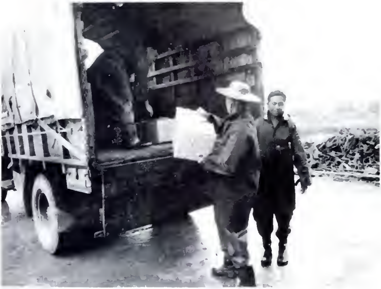

Figure 70 Fry transport in baskets (Photo: F. Botts)

The stocking rate (g/litre) of the fry in the plastic bag depends on the species, temperature, transport time, the individual size of the fry, their physical condition and their degree of 'training'. Stocking rate tables were prepared on the basis of experience. At the fry-rearing centre visited 20-24 h transport is organized for eight-day old fry. Each plastic bag contains eight litres of water. The stocking rate for this bag would be 80 000-100 000 grass or silver carp fry or 150 000 mud carp fry.

The following are a few practical points which must be borne in mind in order to increase the fry's chances of survival:

(a) The physical condition of the fry must be even better when the duration of the transport is long. Fry which are to be transported over long distances must be specially prepared and only healthy specimens must be selected;
(b) Before transport, the fry undergo one to three 'training' sessions, so as to increase their physical resistance and clean out their stomachs and intestines (Section 5.2), and
(c) The plastic bags must be well-inflated with oxygen to 80 percent of their capacity and then be regularly checked during transport. Any air or water leakages must be repaired immediately.

13.1.2 Cost and selling prices of fry

The selling price is fixed by the Government of each province. It also varies according to the species and size of the fry (Table 38). As an indication, the cost prices given by the Chinese technicians are also mentioned, although it is difficult to give an exact definition for each case of the real basis on which these prices were calculated. It appears that in almost all cases, amortization of fry-rearing installations is not included.

13.2 Distribution and Marketing of Food-Fish

13.2.1 Transport of food-fish

Over short distances, either in the farm itself or in the people's commune, the locally produced food-fish is usually transported live, in large waterproof canvas or wooden containers. They are first weighed dry, in a woven basket, at the pond's edge (Figure 76).

Table 38

Cost price and selling price of fry in 1980

Province	Age/size of fry	Species Chinese carp	Price (Y)	
			Cost price	Selling price
Guangdong	8 days	mud carp silver and bighead carps grass carp	- - -	Y 2/10 000 Y 4/10 000 Y 5/10 000
	3 cm	mud, silver, bighead and grass carps	Y 30+/10 000	Y 36.8/10 000
Hubei	8 days	silver, bighead, grass carps	-	Y 4.99/10 000
	13 cm	silver, bighead, grass carps (in cages)	Y 200/10 000	-
	17 cm	silver, bighead, grass carps (in ponds)	Y 300-600/ 10 000	-
Zhejiang	150 g	silver, grass, bighead carps (in cages)	Y 1.04/kg	Y 1.30/kg

When the fish is to be sold outside the people's commune, larger transport facilities are used. These usually include the transport of live fish in boats, whose holds are arranged in perforated compartments in which a small current of water circulates. The tonnages of these boats vary between 3 and 30 t (Figure 73).

The study group observed the first stages of the marketing circuit of farm-reared fish when it visited the Leliu People's Commune (Guangdong). Fish, stored in a channel, were harvested with seine nets and placed in light boats, partially filled with water (Figure 71). They were thus transported toward one of the three State purchasing centres a few kilometres away and situated on the edge of a navigable channel in the Xi Jiang delta. There, the fish were sorted by species, weighed and transferred to one of the perforated compartments of an 8-t capacity transport boat (Figures 72 and 73). Several of these boats leave the purchasing centre each day and transport their cargo of live fish to the Guangzhou Aquatic Product Company Centre, 62 km away. From there, the fish are either distributed to the different markets of the town or transferred to other larger boats for export, still alive, to Hong Kong.

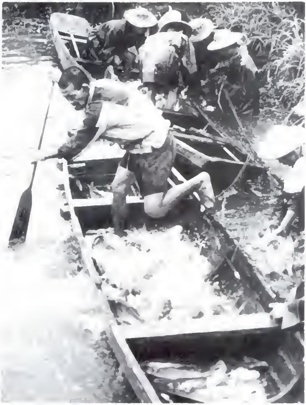

Figure 71 Transporting harvested fish in a flooded boat. Leliu People's Commune, Guangdong

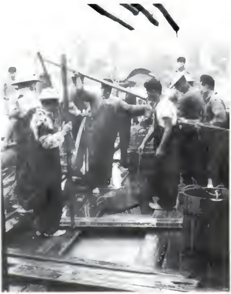

Figure 72 Delivery, sorting and storing of food-fish at the floating purchasing centre

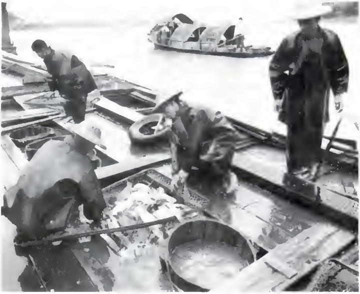

Figure 73 Loading a transport boat with live fish at the purchasing centre. (Photo: F. Botts)

13.2.2 Marketing food-fish

Almost all the farm fish are marketed fresh and a large number are even marketed alive, especially in South China. Once the fish have reached the end of the rearing cycle, they are harvested and if necessary, stocked in storage ponds or channels to await demand before marketing. Every possible effort has been made to locate production zones close to consumption centres, in order to reduce transportation problems to a minimum. The current trend is therefore to intensify fish production in the areas immediately surrounding large towns, such as Shanghai (Section 7.1).

In most people's communes, production meets local requirements. Distribution of fish to members is organized by the marketing centre which serves each production unit. This centre is in fact concerned with purchasing fixed quotas and transporting them to the markets. They work in close collaboration with the producers so as to ensure a regular supply to the market.

Marketing of fish outside the people's communes is controlled and run by the State through purchasing centres. The latter buy the fish directly from the producers (people's commune, State farm, district, etc.), at a fixed price. They transport it, usually alive, to the prefecture, distribution centres, district or province (Aquatic Products Bureaux), from where the fish is transferred to the different markets.

The selling price of the fish is also fixed by the State. It varies in a single province according to the place and the species (Table 39). It can thus be higher in urban than in rural areas. The grass carp obtains a higher price than the other Chinese carps. The black carp, common carp, Wuchang bream and crucian carps can be sold at a higher price than the silver carp, bighead carp or tilapia.

Table 39

Selling price of farm table fish in 1980

Province/ municipality	Producer selling price, Y/kg	
	Silver/bighead carps	Grass carp
Guangdong	1.00	1.50
Hubei	0.62-0.78	1.10
Zhejiang	0.96	-
Jiangsu	1.00[a]	1.30[b]
Beijing	1.50	-

[a] Same price for tilapia

[b] Same price for black and common carps, bream and crucian carps

Market size of table fish also varies according to the region. It seems that in the south, it is larger than in the centre and north. In the Guangdong province, silver, bighead and grass carps are eaten when they reach 1-1.5 kg. In Hubei province, on the other hand, a weight of 0.5-1 kg suffices. Mud carps and tilapia are two relatively small species which are marketed when they reach 125-250 g. Consumers however, prefer the larger specimens.

Average fish consumption in China is currently estimated at around 4.5-5 kg/year *per caput*. Real consumption however varies considerably from region to region. It would appear that some provinces consume very little or no fish at all (e.g., Shanxi). The southern regions of China, however, consume much more than the northern regions. Considerable variations may also exist within a single province. In the Guangdong province, for example, annual average *per caput* consumption is approximately 5 kg in Guangzhou, while in the Leliu People's Commune (Shunde district) it is 50 kg - ten times more.

14. ASSOCIATED INDUSTRIES

14.1 Manufacture of Fish Culture Equipment

As previously mentioned (Tables 14 and 15), most of the people's communes have set up small industries. Since fish culture is currently turning toward mechanization, an increasing number of these industries are showing an interest in producing fish culture equipment. In Shanghai, the study group visited the factory run by the 'Liberation' People's Commune (Qingpu district), which manufactures this type of equipment in four workshops and employs 400 persons.

Production is varied and includes:

- floating paddle aerators equipped with a 0.26 to 5.25-hp electric motor (Figure 74);
- a press for making dry, non-floating granules, fitted with a 5.25 to 11.9-hp electric motor; annual production: 20 units;
- Machines for making dry, floating granules (pressurized steam), fitted with a 5.5 to 11.9-hp electric motor; annual production: 50 units;
- Pumps for cleaning pond bottoms: 150 units/year;
- Metal crates for transporting live fish: 30 units/year, and
- Water purifiers: 15 units/year.

The manufacture of floating granules was demonstrated using a press fitted with a 7.7-hp (11 kW) electric motor, which produced an average of 150 kg/h of grass carp feed (Section 7.1) This device was selling at Y 15 000.

14.2 Aquatic Products Treatment Plant

Aquatic products from inland water areas in China are only rarely treated, e.g., using ice to improve storage. For marine products however, the treatments are many and varied to cover production of different sub-products to be consumed locally or for export.

The study group visited the Shanghai Treatment Plant for Aquatic Products, where 1 800 employees can treat a daily average of 200 t of fish (fresh or frozen) and transform them into 43 different products (Figure 75). The plant is sub-divided into six specialized workshops as follows:

- preserved fish: production of 2 000 t/year of fried and sterilized fish in jars, as well as dried fillets, mainly from the marine fishery of filefish, *Cantherines* (= *Navodon*) *modestus*;
- fish meal: production of 1 000 t/year using rotten fish and various fish residue;
- fish oil: manufacture of gelules and vitaminized pills, mainly using shark liver oil;
- medicinal: production of hydrolysed oil for medicinal purposes;
- chemicals: various, by microbial transformation of fish meal, and
- ice: production of 500 t/day of 100 kg blocks of ice for the marine fishing boats.

15 CONCLUSIONS AND RECOMMENDATIONS

15.1 Organization of Study Tours

The organization of the study tour was excellent on the whole. From their arrival in Beijing until their departure, the participants were taken in charge by their Chinese hosts. The overall programme prepared at the outset was rigorously respected in each province and municipality visited. In three weeks of intensive exchanges, this programme made it possible for the many aquacultural activities in five different regions to be fully appreciated.

It became obvious during the tour however, that some improvements could be envisaged for future similar tours. Participants suggestions refer mainly to the different briefings of a general nature which were given upon arrival in each province and municipality. It soon appeared, that in spite of the commendable efforts of the translators, many difficulties kept arising, for example, the names of people and places. It was also very difficult for the participants to follow the proposed itineraries and to be aware of the geographical location of the places visited or mentioned during discussions.

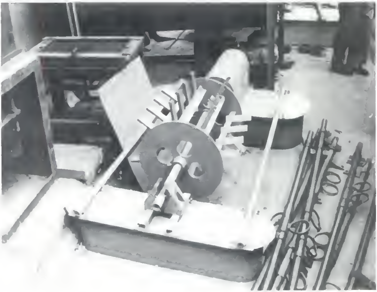

Figure 74 Floating paddle aerator fitted with an electric motor, Fish Culture Equipment Factory, 'Liberation' People's Commune, Qingpu district, Shanghai

Figure 75 Visit to the fish canning factory, Shanghai Aquatic Products Processing Plant

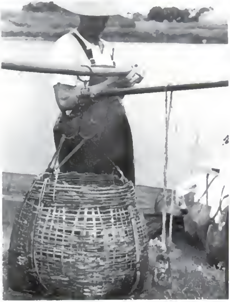

Figure 76 Weighing the harvest at pond's edge

We therefore recommend that for future study tours, greater use be made of audio-visual aids, both for general introductory briefing in Beijing, as well as for later regional briefings. If we take aquaculture, for example, a general briefing could be based on a standard set of slides giving in the form of tables, maps and diagrams, the basic data given in the first four Sections of this report: topography and climatology of China; general administrative organization; aquatic resources; aquatic products; main fish culture species; systems of cultivation; history and analysis of development; central, regional and local organization of aquaculture; research/training. A verbal presentation of this kind should include written diagramatic documentation distributed to each participant. This in turn should include an administrative map of China, showing the general itinerary of the tour, as well as the overall tour programme, the names of the places to be visited and the people to be met. During the regional briefings, this material would be supplemented by more specific data, such as a detailed programme of local visits, the names of places to be visited and people to be met, a schematic map of the regional itinerary. Not only would this material facilitate the task of the interpreters, but would also allow participants to concentrate more on the purely technical aspects of the tour, while being able to refer to the documents at their leisure.

In the course of their visits to the fish farms, the participants immediately realized that these farms were much more successful when organized according to a definite plan. After a brief introduction by the technician in charge, giving a general idea of the main points of the visit, the participants toured the fish culture installations, where on-the-spot descriptions and explanations were given of equipment and techniques used. At the end of the visits a general discussion took place on the main subjects observed during the visit.

15.2 French-Speaking Africa and the Lessons Learnt from Chinese Aquaculture

The purpose of the study tour was to observe the development of Chinese aquaculture in inland waters and at the same time, obtain information on the organizational and technical aspects of this development. As a result of their observations, the participants would be in a better position to assess the possibilities of transferring the technology to their own countries.

All the participants were favourably impressed by all that the Chinese had accomplished in the field of fish culture. It soon became clear to them however, that it would be difficult to copy what they learnt and hope to obtain the same results. There are too many differences between Africa and China, as regards available resources, national needs, social structures, economic systems, etc. The climate and the water resources can be very different. Even the fish species are essentially different. Not only did the African participants therefore have to take an interest in the technical aspects, but, more importantly, in the guiding principles which made this rapid development of aquaculture possible in the Chinese rural environment.

There is no doubt that one of the major reasons for this success lies in the long tradition of fish culture and relatively intensive farming in the inland waters of China. There is no such tradition in Africa and this is a clear handicap. A similar situation concerns command of the water, which is another major asset in China and which in Africa is found on a comparable scale only in Madagascar.

Integration of fish culture into other production activities, allowing maximum utilization of land and water resources, is the most outstanding aspect of Chinese aquaculture. Integration can be applied directly to rural development programmes in Africa, even though it may not be possible to transplant the system observed during the study tour in its present form. Fish species, as well as the types of cultivation and rearing methods must be chosen according to local conditions. In recent years, efforts have been made in several of the participants' countries (e.g., Central African Republic, Congo, Ivory Coast, Madagascar) to introduce and develop this type of integration. Many opportunities also exist in other countries (Cameroon (United Republic of), Gabon, Guinea, Upper Volta, Rwanda, Senegal, Zaire) and they should be exploited as far as possible.

Organization and planning of aquaculture development in China are of course adapted to the social and political system of the country. Major difficulties of adaptation would be encountered in most of the participants' countries. Nevertheless, it appeared that two major principles could be applied:

(i) The value of a central organizing body, which would be independent and specialized in aquatic products, in charge of fresh, brackish and sea water, be it at research, training or production levels, and
(ii) The opportunities offered by decentralized planning at local level, to meet local needs, to mobilize the rural masses to implement the plans and thus achieve real integration.

Scientific research in aquaculture is conducted not only in the specialized laboratories of the institutes and universities, but also at all intermediate levels up to production brigade level, in the very heart of the rural environment. Close ties exist between the different research units at people's commune, district, provincial and national levels, which ensures the coordination, control and support necessary at all levels. This close relationship between researchers and producers makes it possible for the results of scientific research to be put into practical application and not remain theoretical, as usually happens in many other countries.

Training and education in aquaculture are also directed toward integration of the practical with the theory: theoretical teaching and practical experience are closely related. Technicians and rural fish culturists are trained locally in the communes and production brigades, by teachers from technical schools and even universities. This allows the latter to find solutions to existing production problems on the spot. Rural producers can however, also obtain theoretical training in specialized centres, while at the same time working on practical aspects and on solutions to fish culture problems.

The application of the 'three in one' principle to planning, research and aquacultural training results in very efficient rural extension. Among the results that the members of the study tour were able to appreciate were those obtained at fish production level.

Simultaneous development of all local resources is widespread in China and application of this principle is valid for most of the participating countries. For example, aquatic plants, considered a nuisance and removed in many countries, are systematically cultivated in China and used for animal feeding and for making compost. Use of silt from ponds, lakes and rivers for organic fertilization and improvement of soils, as well as the use of molluscs for animal feeds, are two further examples.

During the study tour, the participants were able to get to know the different farming systems used either in ponds, lakes, rivers or channels. In ponds, the farming system is usually semi-intensive, based on polyculture, organic fertilization and plant feed. In open waters, on the other hand, it tends to be extensive, based on natural food and periodic stocking of young fish. Although the species native to Africa are not the same, many of the principles of management applied in China could be successfully adopted there.

Two major recent developments in Chinese aquaculture are controlled spawning of Chinese carps and large-scale production of Chinese carp fry. The first problem does not yet exist in Africa, where raising of the different species of tilapia is possible with natural spawning methods. There are some exceptions however, where, for example, attempts are being made to develop cultivation of catfish (e.g., Cameroon (United Republic of), Central African Republic) or common carps (e.g., Cameroon (United Republic of), Central African Republic, Ivory Coast, Madagascar) or Chinese carps (e.g., Ivory Coast, Madagascar). In these particular cases, more use could and should be made of the Chinese experience with controlled spawning. On the other hand, large-scale production of fry in the rural areas of Africa has not yet been done, even for tilapias. While in China, large quantities of fry are very often produced locally by the peasants themselves, in Africa, this technique, when it exists, is still the domain of the technicians and the State-run fish culture centres. There again, decentralization of fry rearing, as done in China, could be adapted and encouraged and this would make up for the present shortage of stocking material and ease the difficulties of distribution over vast areas in the absence of an adequate communications system.

Once sure sources of fry become available, it will be possible to adapt the Chinese system of semi-intensive fish farming fairly easily to some African regions, first of all where integrated rural development exists and where producer associations are established, e.g., in a cooperative form as in Cameroon (United Republic of), Congo, Ivory Coast, Rwanda and Zaire. In the absence of a well-defined technology allowing polyculture production of a large number of African species, mixed farming of *Sarotherodon niloticus* (plankton feeder) and *Tilapia rendalli* (macro-phytophagic) can give excellent results provided that organic fertilization and feed based on plants and agricultural by-products are applied in accordance with the Chinese semi-intensive system of cultivation.

There seems to be a need however, to develop more complete systems of polyculture in research stations and in Africa, using native species (i.e., different tilapias, catfish) and if necessary, exotic species (e.g., Chinese and Indian carps).

The study group was able to observe on several occasions how skilful application of fish culture techniques to fishery development could be profitable in natural lakes and reservoirs. Extensive polyculture allows complete use to be made of natural food and sometimes even residues from nearby lands. Annual stocking maintains high levels of production. Integrated development of watersheds (e.g., forests, agriculture, livestock farming, fisheries, tourism) guarantees protection of the latter, while optimum use is made of resources. All these aspects and their possible application to developing countries, have been thoroughly dealt with in a previous report (Tapiador, *et al.*, 1977). For Africa, in particular, application of the extensive fish culture techniques used in China could be envisaged, especially in the many small and medium irrigation reservoirs of the Savanna regions in Cameroon (United Republic of), Ivory Coast, Upper Volta, Mali, Niger, Senegal and Togo.

Farming by means of extensive fish culture in pends in sections of rivers and channels also attracted the interest of the participants. Here again, the combination of periodic stocking and polyculture produces attractive output results. However, transfer of this system to other countries, where the notion of collective property ownership and community administration does not exist, could raise various problems, e.g., regarding legislation, environment and management. In most African countries, this type of fish farming is likely to be hard to apply. It could however, be possible in certain cases, such as downstream from hydro-electric dams and in certain seasons, as well as in the main irrigation canals of agro-industrial complexes, when there is no chemical pollution.

On the other hand, special attention must be paid to the use of fish culture pens in African lakes and reservoirs. Although the participants had the opportunity of observing only one of this type of installation - fry production in a bay in a reservoir - they expressed unanimous interest in the export of this technology to their countries. Unfortunately, no experiment of this type has yet been tried there on a large scale. Research on this subject, with a view to producing not only stocking fingerlings, but also table fish, using a semi-intensive system of cultivation, should be undertaken in Africa.

Cage farming whether carried out in reservoirs, rivers or navigable channels, aroused the most interest. All the systems of cultivation - extensive or semi-intensive, in floating or fixed cages, at experimental, pilot or commercial level - have unquestionable potential for the African countries. Before they could be disseminated however, the problem of regular supplies of fry of the species chosen would have to be solved - in this case an African tilapia and preferably *S. niloticus*. If abundant natural food is not available in the cages, good quality artificial feed will have to be provided, using for example, agricultural by-products available locally. Africa already has some experience in these fields (e.g., Benin, Ivory Coast) and there are many opportunities for their development in most of the participating countries. Rapid progress could be made, as in China, provided that the necessary inputs were available.

To conclude, several of the principles to which success of the large-scale development of Chinese aquaculture over the last 30 years is due, could be applied in Africa. These principles refer mainly to administrative organization on both the national and regional scales, to the planning process, to the organization of research and training, to rural development planning, as well as to the choice of a fish culture technology suited to local possibilities.

The Chinese experience, empirically acquired over several centuries of practice with fishery/fish culture and agriculture/fish culture integration, is considerably valuable to African countries which are interested in integrated rural development. It cannot however, be imported without being adapted to local conditions. In fact, in most of these countries more emphasis will have to be laid on economic, social and nutritional benefits. In order to dispose of the skilled labour needed to make the units economically profitable, it is more than likely that producers' associations will be necessary.

There is great potential in Africa for current Chinese technology adapted to tilapia farming in ponds, pens and cages. Small and medium-size irrigation reservoirs in savanna regions could also be set up along the lines of Chinese installations in this field. These fish culture development potentialities would come to nothing unless large-scale production of fry were carried out and suitable farming systems put into practice. As regards the latter, priority could be given to semi-intensive pond polyculture, semi-intensive cultivation in lake enclosures and to extensive and intensive farming in cages. Research on fine points and pilot assessment projects should in turn provide the bases for fish culture development, within the overall framework of integrated rural development.

15.3 China and the Lessons to be Learnt from Aquaculture in French-Speaking Africa

China has a very long experience in fish and intensified fish culture in combination with crop and livestock farming. The greater part of its success in aquaculture is based, not on scientific results, but on the contrary, on empirism. As they emerge from complete isolation which lasted about 10 years, researchers and technicians feel a great need to find out about the progress made in the rest of the world during that time. The particicpsnts were aware of this throughout their long trip across the country.

Unfortunately, since aquaculture development in Africa is still in its initial stages, little basic technical information could be exchanged with our Chinese hosts on this subject.

Their attention was drawn to some of the progress recently made in Africa: production on a pilot scale of male *S. niloticus* in commercial ponds (Ivory Coast); the establishment of modern, Hungarian-type hatcheries for common and Chinese carps (Madagascar), and intensive farming of tilapia in floating cages (Ivory Coast).

Other African ventures should materialize in the near future and could then become additional sources of valuable information for Chinese technicians. These could include fish cultivation in lagoon enclosures (Benin, Ivory Coast); intensive, commercial farming of tilapia in cages, lagoons (Ivory Coast) and reservoirs (Ivory Coast, Upper Volta); large-scale production in modern hatcheries of catfish fry, *Clarias lazera* (Central African Republic); management of modern hatcheries for large-scale production of common, grass and silver carp fry (Madagascar), and polycultural farming in coastal pilot farms of mullet, *Chanos chanos* and Peneidae shrimp (Madagascar).

There is therefore little to be learnt by China from current achievements in French-speaking Africa. If aquaculture development follows its present course however, an increasing amount of information of interest will appear in the next five years.

15.4 Recommendations

On the basis of the conclusions expressed above, we can offer a series of recommendations. They may be subdivided into two groups, depending on whether they refer to aquaculture development in French-speaking Africa (Sections 15.4.1 and 15.4.2) or China (Sections 15.4.3 to 15.4.8).

15.4.1 Integrated development of fish culture/agriculture/livestock farming

Even though the experience accumulated in China has been empirical, it is extremely valuable for African countries wishing to undertake integrated rural development. For purposes of dissemination, it is recommended:

(a) That stills be prepared illustrating different Chinese techniques in this field directly related to fish culture. These stills would be accompanied by a commentary in French describing in detail the operations shown, and

(b) That a 3-4 month practical training course for French speakers be held in China, during which the African technicians would be lodged in the integrated farms and study the various operations related to fish production.

In fact, these two recommendations could be combined. In addition, it is suggested that they be carried out in close collaboration with the new Main Regional Centre of Wuxi (Jiangsu), which was set up with UNDP/FAO-ADCP assistance and whose primary purpose is to organize training and research on integrated fish culture.

15.4.2 Large-scale production of eggs and fry

One or several species of Chinese carp have already been imported by some African countries (e.g., Ivory Coast and Madagascar), while other countries are planning to do so. There is little doubt that technical assistance will be necessary to establish simple, but productive hatcheries, with a view to producing large quantities of eggs and fry. A similar problem faces certain countries which have imported other exotic species (e.g., common carp) or which are trying to produce local species which do not easily spawn in ponds (e.g., catfish).

In these particular cases, it is recommended that competent Chinese technicians be called upon to launch systems suited to local conditions.

15.4.3 Research on integrated systems

Research must be carried out in China to establish scientific bases for techniques which are used empirically in integrated fish culture/agriculture/livestock farming development. A critical and rational analysis of results observed is required if the high outputs obtained locally and sporadically are to be the general rule. This analysis is also absolutely necessary if the real nature of the mechanisms involved are to be understood. It would then be possible to adapt them to new situations and to apply them with as much success.

The Main Regional Aquaculture Centre at Wuxi (Jiangsu), one of the four regional centres forming the Asian network (Project UNDP/FAO-RAS/-16/003), which was opened this year, was designed for this purpose. Chinese technicians receive specialized training in this field, basic and applied scientific research is carried out and an information centre specializing in integrated aquaculture will be set up.

15.4.4 Improvement of hatchery technology

The technology used for controlled spawning of brood fish, incubation and hatching of eggs in Chinese hatcheries is relatively simple, even though it enables massive quantities of fry to be produced. Although the installations are not costly and are easy to maintain, they do not allow effective control to be exercised over the different production phases, such as fertilization, incubation, hatching and the removal of dead/diseased eggs. This could explain the relatively low rates of fertilization and hatching which have been noted in some hatcheries.

It would be useful to compare the results obtained using this technology with those obtained using modern technology which allows a tighter control to be kept on all phases. This could include artificial fertilization, the use of methods to encourage fertilization, the use of incubating jars, as well as the use of chemical treatment during and at the end of incubation, according to the methodology successfully applied on a large scale in Hungary.

To enable Chinese technicians to familiarize themselves with this new methodology, it is recommended that two to three month-long practical training courses be held for them at the Szazhalombatta hot water hatchery in Hungary. These courses could be followed by a one to two week stay at the hatchery of the Organization for the Improvement of Inland Waters (OVB) in Lelystad, Holland, during the common and grass carp production season.

15.4.5 Improving cage farming technology

On the basis of observations made during visits to some installations and the technical data obtained, it would appear that currently used technology could be substantially improved. Yields are in fact rather low, especially when relatively rich artificial feeds are used. This may be due to several reasons: e.g., use of nets whose meshing size is too small (loss of water exchange) and too low stocking densities and rates.

It is recommended that study tours and short practical training courses be organized for Chinese technicians in institutions and commercial installations with a solid experience in fish production in cages. As far as cage cultivation in China is concerned, the following countries are experienced on the subject: USA (trout, tilapia, catfish); Hungary (Chinese carps, pike-perch, sturgeon); Holland (common carp, grass carp, rainbow trout); Philippines (tilapia), and the German Democratic Republic (common carp, rainbow trout).

15.4.6 Intensive pond farming

There is an increasingly urgent need to set up intensive fish culture farms in suburban zones in eastern China. Trials are underway, but most of them have not yet reached pilot stage. To accelerate development of these farming systems, and so that they may benefit from the experience gained by other countries, it is recommended that study tours and practical training courses be organized for small groups of Chinese technicians. During these visits, they could be shown intensive farming in raceways and round ponds, technology using water recirculation, manufacture and distribution of artificial feeds, as well as modern methods for manipulating cultivated animals. Aspects regarding economic profitability of intensive farming should also be closely examined. Visits could be organized to the USA, Great Britain, Italy and Japan, to both Government and private installations.

15.4.7 Technical literature

As previously mentioned, China's complete break with scientific research and technological development in foreign countries over the last 10 years constitutes a serious handicap today, in spite of recent efforts in opening their doors to the outside. Their research institutes, centres of higher education and their technicians are desperately in need of foreign publications and reference material relating to recent developments in aquaculture and related sciences.

It is recommended that in every province, municipality and autonomous region where aquaculture plays an important role, a specialized documentation centre be set up and equipped. Basic modern documentation should be provided, in the form of microfiches, for example. Equipment for reproducing the latter would allow them to be distributed on a large scale and cheaply to specialized institutions in the region, which would also be equipped with microfiche readers. It is furthermore recommended that these centres be established in close collaboration with the UNDP/FAO Documentation Centre in Wuxi (Main Aquaculture Regional Centre - Asia network). Training courses could also be held for the people who will run the new documentation centres.

15.4.8 Future collaboration with FAO

The foundations for close collaboration with FAO have been laid, in particular with the Fisheries Department, through its Inland Water and Aquaculture Resources Service (FIRI) and its Aquaculture Development and Coordination Programme (ADCP). This collaboration should not only be pursued, but it should be strengthened in the coming years, mainly through common interest for establishing and developing the Main Aquaculture Regional Centre in Wuxi.

It is recommended that within the framework of this collaboration, more encouragement be given to exchanges of information between FAO technicians and technicians from the National Bureau of Aquatic Products. The exchanges should be in the form of working sessions and the provision of specialized publications.

REFERENCES

ADCP (Aquaculture Development and Coordination Programme), Aquaculture development in
1979 China. Rome, FAO, ADCP/REP/79/10:65 p.

FAO, Learning from China. A report on agriculture and the Chinese People's Communes.
1977 Bangkok, FAO, 112 p.

Nikol'skii, G.V. (J.I. Lengy and Z. Krauthamer, Transl.), Special ichthyology. Jerusalem,
1961 Israel, Program for Scientific Translations, IPST Cat. No. 233:475 p. Transl. of 2nd ed. (1954)

Pagán-Font, F.A. and J. Zinet, Rearing fry and fingerlings of Chinese carps. Filmstrip
1980 and commentary. Rome, FAO, 114 photos

Solecki, J.J., Economic aspects of the fishing industry in mainland China. Vancouver,
1966 University of British Columbia, 172 p.

Song, Z., Manual of small-scale reservoir fish culture. FAO Fish.Circ., (727):18 p.
1980

Tapiador, D.D., *et al.*, Freshwater fisheries and aquaculture in China. A report of FAO
1977 Fisheries (Aquaculture) Mission to China, 21 April-12 May 1976. FAO Fish. Tech.Pap., (168):84 p. Issued also in French and Spanish

Zhu De-Shan, A brief introduction to the fisheries of China. FAO Fish.Circ., (726):31 p.
1980

Anon., Pond fish culture in China, Guangzhou, China. China National Bureau of Aquatic
1980 Products, Pearl River Fisheries Research Institute, 136 p.

Table of Conversion Factors

1 mu	0.067 ha
1 mu	666.67 m^2
1 ha	15 mu
1 jin	0.5 kg
1 kg	2 jin = 1 gungjin
1 jin/mu	7.5 kg/ha
Yuan 1 (Y)	US$ 0.667
US$ 1	Yuan 1.5 (Y)

Chinese-English Glossary

Hai	Sea
He	River
Hu	Natural lake
Jiang	River
Shui hu (S.k.)	Reservoir, artificial lake
Tatsao	Mixture of different soft, young, putrescible herbaceous plants, used as organic manure

List of Abbreviations

NBAP	National Bureau of Aquatic Products, Beijing
BAP	Bureau of Aquatic Products (regional)
DAP	Department of Aquatic Products
DFA	Department of Foreign Affairs
P.C.	People's Commune
A.R.	Autonomous Region
A.D.	after Jesus Christ (*Anno Domini*)
A.C.	before Jesus Christ (*Ante Christum*)

max.	maximum
min.	minimum
av.	average
No.	number
ppm	parts per million
t	metric ton
tot.	total
Y	yuan

APPENDIX 1

List of the Members of the Study Group

Study tour on Aquaculture Development in China
(22 April to 21 May 1980)

Country	Name	Position/Address
Benin	Mr Barnabé Kpogbezen	Director, Fish Culture Development Project, Cotonou
Cameroon (United Republic of)	Mr Jean Calvin Njock	Chief, Aquaculture Research and Documentation Service, Department of Fisheries, Yaoundé
Central African Republic	Mr Léon Mbangessi	Director of Fisheries, Bureau of Water and Forests, P.O. Box 830, Bangui
	Mr Adrien Marasse	Chief, Department of Water/Fisheries/ Fish Culture, Bureau of Water and Forests, P.O. Box 830, Bangui
Congo	Mr Jean-Pierre Loufoukou	Chief, Department of Fisheries and Fish Culture, Bureau of Water and Forests, P.O. Box 98, Brazzaville
Gabon	Mr François Ngoua	Chief, Fish Culture Department, Bureau for Hunting/Fisheries, P.O. Box 1128, Libreville
Guinea	Mr Toure Dansoko	Chief, Fish Culture Station, Mamou
Ivory Coast	Mr Mamadou Diarra	Assistant Director, Bureau of Fisheries/ Continental Fish Culture, P.O. Box V94, Abidjan
	Mr Konao Boidy	National Director, UNDP/FAO Project, Fisheries/Aquaculture Development, P.O. Box 494, Bouaké
Madagascar	Mr Andriamahaly Rasolo Fo	Chief, Division of Fisheries/Fish Culture, P.O. Box 243, Antananarivo
	Mr Alexandre Rabelahatre	National Director, UNDP/FAO Project, Fisheries/Fish Culture Development, P.O. Box 243, Antananarivo
Mali	Mr Toumani Traore	Chief, Fisheries Division, P.O. Box 275, Bamako
Niger	Mr Mounkeila Goumandakoye	Assistant Director of Water and Forests, P.O. Box 578, Niamey
Rwanda	Mr Joseph Ruremeshe	Chief, Division of Fisheries and Fish Culture, Bureau of Water and Forests, P.O. Box 621, Kigali
Senegal	Mr Papa Baidy A. Sy	ITEF/IREF Fleuve, P.O. Box 229, St. Louis
Togo	Mr Bagnindama Aouissa	Chief, Fisheries Department, Kante
Upper Volta	Mr Julien Thiombieno	Director, Fisheries and Fish Culture, P.O. Box 7044, Ouagadougou
Zaire	Mr Ilunga Lomami	Chief, Natural Resources Management Division, P.O. Box 5036, Kinshasa 10
FAO/HQ	Dr André G. Coche	Team Leader I, Senior Officer (Aquaculture), Inland Water and Aquaculture Resources Department, Fisheries Division, FIRI/FAO, 00100 Rome, Italy
FAO/Africa	Dr W.Q.-B. West	Team Leader II, Regional Officer, Fisheries FAO Regional Office for Africa, P.O. Box 1628, Accra, Ghana

APPENDIX 2

Itinerary and Programme of the Study Group

Tuesday, 22 April 1980

- Study group meets at the Charles de Gaulle Airport, Paris, under the FAO/Africa Team Leader
- Flight to Beijing from Paris (CA 934)

Wednesday, 23 April 1980 - Beijing

- Study group arrives from Paris, welcomed by the Representative of the National Bureau of Aquatic Products and by the FAO/HQ Team Leader
- Discussion of the study tour itinerary with Representatives of the International Division of the Foreign Affairs Department, National Bureau of Aquatic Products
- General briefing of the participants by the FAO/HQ Team Leader

Thursday, 24 April 1980 - Beijing

- Guided tour of the Imperial Palace
- Introductory briefing on aquaculture in China by the Chief of the International Division, FAD/NBAP
- Banquet hosted by NBAP

Friday, 25 April 1980 - Beijing

- Shuangqiao People's Commune
- Guided tour of the Summer Palace, Beijing

Saturday, 26 April 1980 - Guangzhou - Guangdong province

- Flight from Beijing - Guangzhou
- Briefing by the Bureau of Aquatic Products of the province
- Evening at the theatre: songs and dances

Sunday, 27 April 1980 - Guangzhou - Xinhui

- Leliu People's Commune - Shunde district
- Journey by road to Xinhui (Xinhui district)
- Briefing by the Department of Aquatic Products of the district

Monday, 28 April 1980 - Xinhui

- Hengjiang Fry-Rearing Centre - Xinhui district
- Tangxia People's Commune: extensive fish culture in rivers
- Overnight in Xinhui

Tuesday, 29 April 1980 - Xinhui - Guangzhou

- Guided tour of a palmyra leaf processing plant
- Workers University for Agriculture and Forests, Xinhui district
- Return journey to Guangzhou by road
- Meeting of the study group

Wednesday, 30 April 1980 - Guangzhou

- Zhu Jiang Institute of Aquatic Products
- Trade Fair and Friendship Shop

Thursday, 1 May 1980 - Wuhan - Hubei province

- Flight from Guangzhou - Wuhan
- Briefing by the Provincial Bureau of Aquatic Products

Friday, 2 May 1980 - Baitan Hu

- Baitan Hu State Farm, Huanggang prefecture
- Evening at the cinema and accommodation at the farm

Saturday, 3 May 1980 - Xishui

- Bailianhe Reservoir, Xishui and Yingshan districts
- Accommodation in the Xishui district

Sunday, 4 May 1980 - Xishui - Wuhan

- 'October' Production Brigade, Xishui district
- Return journey to Wuhan by road

Monday, 5 May 1980 - Wuhan - Shanghai - municipality of Shanghai

- Hydrobiology Research Institute of Hubei
- Flight from Wuhan - Shanghai
- Briefing by the Bureau of Aquatic Products of the municipality

Tuesday, 6 May 1980 - Shanghai

- Dianshan Hu, Qingpu district
- 'Liberation' People's Commune: fish culture equipment plant
- Fish Culture Centre of the Qingpu district
- Meeting of the study group

Wednesday, 7 May 1980 - Shanghai

- Aquatic Products Research Institute of Shanghai
- General meeting of the scientific staff of this institute and the members of the study group: presentation of national reports by the latter and of slides by the FAO/HQ Team Leader

Thursday, 8 May 1980 - Shanghai

- Shanghai Aquatic Products Processing Plant
- Friendship Shop
- Evening entertainment: Shanghai acrobats

Friday, 9 May 1980 - Shanghai

- Visit: jade and ivory sculpture factory
- Shanghai permanent industrial fair

Saturday, 10 May 1980 - Hangzhou - Zhejiang province

- Train journey Shanghai - Hangzhou
- Briefing by the Provincial Aquatic Products Bureau
- Visit to Xi Hu by boat
- Visit to tourist sites near the lake

Sunday, 11 May 1980 - Hangzhou

- Qingshan Reservoir - enclosures and cages
- Fish Culture Centre at the dam
- Hangzhou Aquatic Products Experimental Centre
- Evening at the theatre - Shanghai opera

Monday, 12 May 1980 - Hangzhou

- Fish Culture Centre Annex - district of Shaoxing
- Tourist visit of the east lake - Shaoxing
- Visit to the Lu Hsun Museum/house where he was born

Tuesday, 13 May 1980 - Hangzhou

- Tourist tour to the outskirts of Hangzhou
- Guided tour of a textile factory
- Friendship Store and foreigners' library

Wednesday, 14 May 1980 - Wuxi - Jiangau province

- Train journey: Hangzhou - Shanghai - Wuxi
- Briefing by the Wuxi Department of Water and Forests
- Hele People's Commune - Fish Culture Centre

Thursday, 15 May 1980 - Hangzhou

- Tai Hu: visit by boat and briefing
- Tourist visit to the outskirts of Tai Hu
- Hele People's Commune - Production Team No. 2

Friday, 16 May 1980 - Hangzhou

- Hele People's Commune: presentation of four national reports - Madagascar, Benin, Central African Republic and Ivory Coast - by the country representatives. Technical show and commentary by the FAO/HQ Team Leader
- Meeting of members of the study tour

Saturday, 17 May 1980

- Guided tour of a textile and figurine factory
- Overnight train (wagon lit), Wuxi - Beijing

Sunday, 18 May 1980 - Beijing

- Arrival in Beijing and transfer to hotel
- Tourist visits - Ming tombs and the Great Wall
- Evening at the theatre

Monday, 19 May 1980 - Beijing

- Final meeting, in the presence of the Assistant Director of the National Bureau of Aquatic Products
- Visit to the Friendship Store
- UNDP office briefing on the study tour

Tuesday, 20 May 1980

- Flight Beijing - Paris (CA 933)
- Arrival in Paris - group dispersed

APPENDIX 3

Persons Met by the Study Group

1. Person in charge (23 April-20 May 1980)

Li Renpei	Chief, International Division, Foreign Affairs Department (FAD), National Bureau of Aquatic Products (NBAP)

2. Interpreters (23 April-20 May 1980)

Jia Yali (Ms)	Officer, International Division, FAD/NBAP
Xi Jingming	Officer, Ministry of Land Reclamation

3. Beijing (23-24 April and 18-19 May 1980)

Xio Fong	Assistant Director, NBAP
Liu Lechuan	Director, FAD/NBAP
Yang Xianzhang (Ms)	Chief, International Division, FAD/NBAP
Jiu Shisheng (Ms)	Officer, FAD/NBAP
Zhu Deshan	Research Assistant, Bureau of Aquatic Products - Huang Hai

Shuangqiao People's Commune (25 April 1980)

Yu Shihe	Bureau Chief
Zhou Shiping	Assistant Director

4. Guangdong province

Guangzhou (26 April-1 May 1980)

Liu Zhongying	Chief, Department of Economic Relations with Foreign Countries, Provincial Bureau of Aquatic Products (BAP)
Ye Huanqiang	Officer

Leliu People's Commune (27 April 1980)

Lu Huiyuan	Bureau Chief
Lin Rongqie	Hatchery Technician
Du Weisheng	Person in charge of pond fish culture
Wu Qingqiu	Officer, Department of Foreign Affairs
Yun Rensheng	Technician, Aquatic Products Department (APD), Shunde district

Xinhui district (28-29 April 1980)

Zhang Fuzheng	Director, district APD
Wang Jinman	Technician, district APD
Chen Jinwang	Officer, Department of Foreign Affairs

Hengjiang Fry-Rearing Centre (28 April 1980)

Jien Lianxin	Director
Liang Weiquan	Assistant Director
Ye Shengjian	Fish Culture Technician
Chen Guoying	Fish Culture Technician

Tangxia People's Commune (28 April 1980)

Chen Enyao	Committee Chief
Lu Shaoliu	River Dam Chief
Cheng Hong	Chief of Community Enterprises

Workers' University (Agriculture and Forests), Xinhui district (29 April 1980)

Huang Ziyue	Bureau Chief

Zhu Jiang Aquatic Products Institute (30 April 1980)

Zhong Lin	Assistant Director/Professor
Li Yougang	Research Assistant/Teacher
Zao Zhenliang	Research Assistant/Teacher
Si Guangbi (Ms)	UNDP/FAO training course interpreter

5. Hubei province

Wuhan (1-5 May 1980)

He Yukang	Chief, Division of Technical Sciences provincial DAP
Wang Kejun	Secretary, provincial DAP
Zhu Xihan	Technician, provincial DAP

Huanggang prefecture (2-4 May 1980)

Zhu Guoxiang	Assistant Director, prefecture DAP
Xi Shaoreng	Head of Department, prefecture DAP
Cao Pinshan	Director, Huanggang district DAP

Baitan Hu State Farm (2-3 May 1980)

Wang Xiangcai	Director
Wu Peilian	Fish Culture Technician

Bailianhe Reservoir (3 May 1980)

Cai Qiong	Chief, Management Division
Qian Wanmei	Technician
Ma Guoyen	Director Yingshan district DAP

Xishui district (4 May 1980)

Cheng Guoying	District Assistant Director
Yang Fengjie	District DAP Assistant Director
Sun Yicheng	In Charge, Foreign Affairs Department
Cheng Mengchu	Fish Culture Technician
Cheng Renyou	Chief, Fish Culture Farm, 'October' Production Brigade

Hubei Hydrobiology Research Institute (5 May 1980)

Yan Dashu	Assistant Director/Professor/Ichthyopathologist
Pan Jinpei	Research Assistant (Ichthyopathology)
Wan Peirui (Ms)	Research Assistant (Aquatic ecology)
Cheng Xiyu	Research Assistant (Taxonomy)

6. Municipality of Shanghai

Shanghai (5-10 May 1980)

Xu Zhuan	Chief of Division, Shanghai DAP
Zheng Liang	Head of Department, Shanghai DAP
Cao Pinmei	Officer, Shanghai DAP
Chen Zhongrun	Interpreter

Qingpu district (6 May 1980)

Xiao Shenluo	Chief, Dianshan Hu Fish Culture Station
Shen Qingsheng	Officer-in-Charge, District Fish Culture Centre
Zhu Qinglin	Chief of Production Team, Fish Culture Centre

'Liberation' People's Commune (6 May 1980)

Gu Chuxi	Officer-in-Charge
Li Jinlong	Senior Officer
Gu Weiming	Chief, Fish Culture Equipment Plant

Aquatic Products Research Institute (7 May 1980)

Jiang Yuting	Officer-in-Charge of the Bureau
Wang Xijun	Officer-in-Charge, Research Bureau
Guo Luji	Research Assistant (Nutrition/Technology)
Guo Wenyu (Ms)	Technician
Wang Youhuai	Research Assistant, Aquatic Products Institute, Dong Hai

Shanghai Aquatic Products Processing Plant (8 May 1980)

Shen Dushen	Assistant Director of the Plant
Wang Shiyang	Assistant Bureau Chief
Chen Podu	Assistant Engineer

7. Zhejiang province

Hangzhou (10-14 May 1980)

Gan Shuguo	Chief, Technical Sciences Division, provincial DAP
Yu Hanshun	Head of Department

Xi Hu Fish Culture Station (10 May 1980)

Zhu Zhiqun	Officer-in-Charge
Li Meizhi	Fish Culture Technician

Quingshan Reservoir (11 May 1980)

Song Jinlin	Director, Management Bureau
Wang Zhongguang	Fish Culture Technician

Hangzhou Aquatic Products Experimental Centre (11 May 1980)

Chen Zhizhen	Chief of Centre
Zhang Hongsen	Assistant Chief
Wang Tugen	Assistant Chief
Li Peiyao	Fish Culture Technician
Qu Haozhe	Fish Culture Technician

Prefecture and district of Shaoxing (12 May 1980)

Fu Baofu	Officer-in-Charge, prefecture DAP
Wang Aoqi	Assistant Director, district DAP
Qian Jinkui	Chief, Main District Fish Culture Station
Jiang Aao	Chief, District Fish Culture Centre Annex

8. Jiangsu province

Wuxi (14-17 May 1980)

Zhang Renxin	Assistant Director, Water and Forest Department
Guo Giuping	Head of Department
Wang Xingming	Assistant Chief, Wuxi Aquatic Products Research Institute

Hele People's Commune (15-16 May 1980)

Liu Weiping	Commune Director
Jing Rongkun	Chief, Fish Culture Centre
Shen Zhonglun	Fish Culture Technician

Foto-Tipo-lito SAGRAF - Napoli

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ISBN 92-5-101113-3